Isaac Lea Esqr
with the respects
of James Hall

MEXICAN BOUNDARY SURVEY.

Part II.

GEOLOGY AND PALÆONTOLOGY.

REPORT

ON THE

UNITED STATES AND MEXICAN BOUNDARY SURVEY,

MADE UNDER

THE DIRECTION OF THE SECRETARY OF THE INTERIOR,

BY

WILLIAM H. EMORY,

MAJOR FIRST CAVALRY, AND UNITED STATES COMMISSIONER.

VOLUME I.

WASHINGTON:
A. O. P. NICHOLSON, PRINTER.
1857.

PART II.

M*

GEOLOGICAL REPORTS

OF

DOCTOR C. C. PARRY AND ASSISTANT ARTHUR SCHOTT.

NOTES BY W. H. EMORY.

PALÆONTOLOGY AND GEOLOGY OF THE BOUNDARY,

BY

JAMES HALL, OF ALBANY, NEW YORK.

DESCRIPTION OF CRETACEOUS AND TERTIARY FOSSILS,

BY

T. A. CONRAD, ESQ.

CONTENTS.—PART II.

CHAPTER I.

GENERAL GEOLOGICAL FEATURES OF THE COUNTRY.

CHAPTER II.

SUBSTANCE OF THE SKETCH OF THE GEOLOGY OF THE LOWER RIO BRAVO DEL NORTE.

CHAPTER III.

GEOLOGICAL FEATURES OF THE RIO GRANDE VALLEY, FROM EL PASO TO THE MOUTH OF THE PECOS RIVER.

CHAPTER IV.

GEOLOGICAL OBSERVATIONS ON THE COUNTRY ALONG THE BOUNDARY LINE LYING BETWEEN THE 111TH DEGREE OF LONGITUDE AND THE RIO COLORADO.

CHAPTER V.

PHYSICAL AND GEOLOGICAL DESCRIPTION OF THE COUNTRY FROM THE INITIAL POINT ON THE PACIFIC TO THE JUNCTION OF THE GILA AND COLORADO.

GEOLOGY AND PALÆONTOLOGY.

GEOLOGY AND PALÆONTOLOGY OF THE BOUNDARY, BY JAMES HALL, OF ALBANY, NEW YORK.

DESCRIPTION OF CRETACEOUS AND TERTIARY FOSSILS, BY T. A CONRAD.

LIST OF MAPS AND ILLUSTRATIONS.

NOTE.—I think it proper to state that I do not concur with Mr. Schott in his conclusion on page 96, where he says: "From this we have the proof of a former immediate connexion in these latitudes between the two oceans of our globe." In the original proof this conclusion was erased, but by some accident was afterwards inserted. W. H. E.

ERRATA.

On page 91, line 41, for "nearly" read near.

CHAPTER I.

GENERAL GEOLOGICAL FEATURES OF THE COUNTRY.

WASHINGTON, D. C., *April* 1, 1854.

Colonel W. H. EMORY, *United States Commissioner:*

SIR: In completion of the duties assigned me as botanist and geologist to the United States boundary commission, I present the following:

I. GENERAL PHYSICAL AND GEOLOGICAL FEATURES OF THE COUNTRY.

The general features of the Mexican Gulf Coast, in connexion with the United States and Mexican boundary line, present a marked contrast with those observed on the opposite Pacific coast. Thus, instead of the high cliffs, abrupt headlands, and general bold and rugged outline exhibited on the Californian coast, the Texan shore-line, throughout its whole extent, presents a uniform, low dead level. Generally, indeed, the main coast is shut in from the open sea by ranges of sand islands formed by the waves of silted sea sand and comminuted shells. Inside of this line of islands shallow bays spread themselves into the indented coast, and here the numerous rivers flowing from the interior meet the tide-water. The tide range is moreover small, and thus the alternating differences of level do not favor the formation of navigable estuaries by which the main land may be approached. These features, collectively, give to this coast an inaccessible character, and serve to render its navigation both difficult and dangerous.

Its rivers are unapproachable, except by vessels of very light draught; while the inlets to its shallow bays, obstructed by variable sand-bars, present obstacles to navigation, sufficiently proved by the numerous wrecks that strew their beach. Proceeding inland from the line of sandy beach, a gentle slope spreads out in a uniform gradually rising plane, composed of dark rich loam, and covered with luxuriant pasturage. The scenery is rarely relieved of its blank outline by a clump of *live oak* trees surrounding a sunken morass. Farther on, at a variable distance of 10 to 20 miles, the surface of the ground shows gentle swells, still maintaining its fertile character, and displaying here and there groves of *post oak* and other timber. The river bottoms adjoining are occupied with a heavy timber growth, principally of *elm*, (*ulmus crassifolia*,) festooned with *Spanish moss*. The undergrowth comprises a complete maze of shrubbery, matted and tangled together by vines and creepers, and supporting a rank annual growth.

At a distance of 50 to 80 miles from the coast, the ground-swells become more abrupt and form distinct ridges, between which are collected the drainage of the country. Along the course of the numerous streams there is an exposure of the geological substratum, consisting first of loose gravelly strata, which contain erratic pebbles of siliceous or calcareous character; to this succeed occasional exposures of a coarse-grained sandstone, No. 1. Still farther inland we meet with a form of soft calcareous earthy rock outcropping along the sides of hills, and constituting the first outlayer of that extensive cretaceous formation which characterizes so large a scope of country throughout middle and northwestern Texas.

From San Antonio, occupying the first step in the cretaceous series, at an elevation of 600 feet above the Gulf of Mexico, proceeding northerly on the line of the lower road to El Paso, we soon remark a rapid change in the general features of the country. The underlying limestone formation becomes more largely developed, and is less deeply covered with alluvial deposits. The rock stratum is frequently exposed in the beds of streams, which are everywhere thickly strewn with the water-worn pebbles of this formation. The streams here acquire an intermittent character, subject to sudden overflow and recession. Their course, when low, is marked by an irregular series of deep basin ponds connected together only by shallow brooks, or even not at all above ground during dry seasons.

As we proceed, mural exposures of limestone rock become more frequent, and the same formation is met with on summits of the higher table-land. The alluvial tracts along the course of the larger valleys acquire a more arid character of soil, and support a stunted timber growth, in which mezquite makes its appearance. Fossil, fresh water, and land shells are quite abundantly scattered over the lower depressions of these alluvial bottoms.

At the crossing of the Rio Frio, near Fort Inge, occurs the first exposure of igneous rock. It is seen as an isolated knoll of dark-colored trap, showing at this place but slight disturbance of the adjacent cretaceous strata. This formation is thence observed to constitute a broken line, extending in a northwest course, and coming into view at several points along the road at variable distances of 5 to 10 miles.

On approaching the line of the great table-land formation of Northwest Texas, we find near its base the sources of most of the minor streams of this region. These sources frequently exhibit magnificent basin springs, of which that at San Felipe is a noted example.

We have here reached the main development of this extensive cretaceous formation, partially concealed from view towards the coast, as above noticed, by alluvial deposits, but here standing out in bold relief, variously exposed in extensive ridges, bounding, more or less closely, valleys

Character of valley denudations in the cretaceous table-land formation. Upper portion of San Pedro river, Texas.

of denudation, or else stretching in vast upland plateaus, thinly covered with soil, and supporting a close even growth of upland grasses or scanty shrubs.

The true character of this formation may be satisfactorily studied in the course of its principal streams, the Pecos and Devil's river. As exposed along the course of these valleys, the view is bounded by steep mural cliffs, composed of limestone, disposed in nearly horizontal strata. This rock exhibits quite a variable texture, its weathered face showing an uniform gray or bluish tint, while its recent fracture has a much lighter color. Owing to its irregular texture, it frequently exhibits a cavernous structure, displaying in its various exposures all the grotesque features of ruined castles, forts, and dilapidated masonry; examples of which may be seen by reference to numerous sketches.

The river valleys either expand into more or less extensive alluvial basins, or are completely hemmed in by steep mural faces, forming chasms along their course, to which the Spanish term of *cañon* is generally applied. Thus, in following out the course of valleys in this district, we have a series of basins connected by cañons; the relative extent of these distinct topographical features being dependent on the local character of the formation, or the varied influence of previous denuding forces.

The alluvial tracts partake to a great extent in the sterility of the plateaus with which they are connected, seldom showing evidence of fertility, and in a great measure destitute of timber growth.

In the case of the Pecos river, which may be regarded as the main type of streams belonging to this table-land formation, we observe a contracted but constant body of water coursing through alluvial tracts, or clearing its way through rocky cañons.

In the former case, its tortuous course is marked out between deep banks of earth, so that its turbid waters are for the most part invisible till you come directly on its brink. The average width of the stream, during most of the year, is about 50 feet, and 8 feet in depth. Only limited portions of the adjoining valley are subject to that degree of overflow, such as constitutes what is commonly understood as bottom-land. Owing to the steep and crumbling nature of the banks, travellers often experience no small difficulty in watering their animals; the water itself, though highly charged with reddish sediment, is not unpalatable.

In its passage through cañons, this stream, like the Rio Grande, cleaves its way between steep walls of rock; its course during low water being occasionally set off by lines of sandy or pebbly beach, and forming frequent rapids.

All the small intermittent streams of this region are copiously bedded with rounded pebbles, derived from the adjoining limestone formation.

The view from the summit elevations presents not an unbroken table-land, but rather a series of terraces, exhibiting occasionally truncated peaks, and showing a general increasing elevation westward. The mean level is, moreover, marked by depressed valleys, containing dry pebbly beds of streams, and frequently expanding into wide basins. The descent to these valleys is generally abrupt, and is the chief obstacle in the construction of roads, which, with this exception, are marked out with ease, and are unexcelled for purposes of wagon transportation.

The supply of water over these arid tracts, except in a season of rain, is confined to a few isolated springs, occupying the lower level of some of these depressed valleys, or occasionally bursting out from the base of high rocky ledges. These springs, though generally affording a copious and constant flow of water, are not sufficient to give origin to river tributaries, their issue being quickly absorbed in the lower course of their arid beds. In several of these springs the temperature is as high as 70° Fahrenheit. Between these watering places occur what are termed by travellers "*dry stretches*," being in some instances 50 miles in extent.

In all our observations thus far, little disturbance is noticeable in the position of the strata. To ordinary view they appear strictly horizontal; the indications of the barometer and the changes of the climate prove, however, a gradually increasing elevation. The height, as indicated at the Leon spring, the most western point of the continuous table-land at which cretaceous fossils were collected, is 2,807 feet. This shows a rise of 1,800 feet from the lowest series of this formation, (the mouth of Devil's river,) and 2,200 feet above San Antcnio, giving an average rise of 7 feet to the mile.

Quite constantly in the distance, to the south and west, rugged mountain ranges are visible, evidently of igneous character, and connected with extensive disturbance of adjacent cretaceous rocks. It is through these, as we shall hereafter see, that the Rio Grande forces its way, presenting a series of chasms and deep cleft cañons of a most stupendous character.

The first indication of a change in the general features of scenery, as sketched above, on the line of the usually travelled road to El Paso, is encountered in the range of the "Sierra Diavolo," or Limpia mountains. This range may be regarded as the southern continuation of the great dividing ridge between the Pecos and the upper Rio Grande, including the Sacramento mountains to the north, the Guadaloupe and Limpia mountains, with their continuation south, to form the Sierra Rica of Mexico; through the latter portion of this range the Rio Grande forces its way a short distance below and east of Presidio del Norte.

This range is characterized, at all the separate points observed, by the presence of igneous rocks, varying considerably in structure and lithological character, as noted by Professor Hall in rock specimens Nos. 12, 13, 14, 15.

The elevation attained by this range, on the line of the El Paso road, is from 5,000 to 7,000 feet above the sea. On entering this range from the east, we pass quite abruptly from the horizontal limestone strata to the igneous exposures.

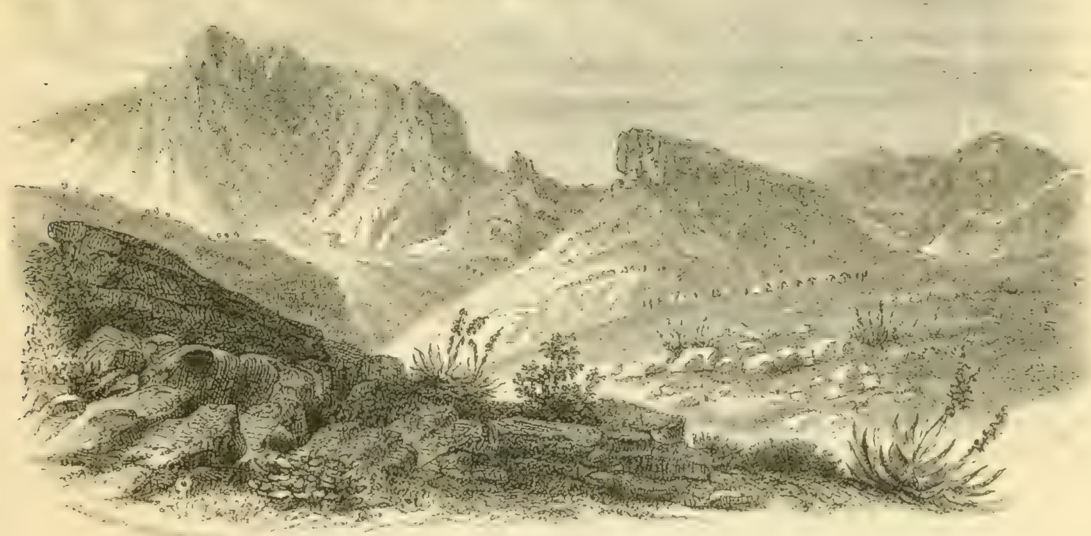
The passage of this range is accomplished by a series of rather steep and rough ascents, following up the course of the Limpia valley. The main pass, known as the "*Wild Rose Pass*," exhibits gigantic walls of rock, towering up on either hand to the height of 1,000 feet or more above the valley below.

The summit divide is composed of a coarsely-grained granitic rock, formed principally of feldspar, and varying in color, in the different exposures, from dark brown to a dull whitish. In descending the more gradual western slope of this range, the rock exposures assume the character of a close porphyritic trap, of a reddish color. As we leave the main range, passing to the west, we encounter extensive ridges of stratified limestone rock, associated more or less closely with interrupted igneous exposures, and showing a general dip to the southwest, or away from the Limpia mountains. The inclination, however, shows, in many places, a variable direction and intensity, depending on local causes connected with adjoining igneous exposures.

A degree of metamorphism is also exhibited in rock exposures, having a gneissoid structure and traversed by quartz veins.

From the specimens collected, imperfectly characterized by fossils, Prof. Hall concludes that these stratified rocks belong to the carboniferous period.

Between these irregular mountain ranges and spurs, which in this section of country meet the eye in every direction, the intervening surface spreads out into wide basin plains of an alluvial character. These basins receive and absorb the scanty streams of the adjoining mountains. Rarely indeed, except in the highest mountain recesses, is running water visible, the occasionally copious rains furnishing only a temporary current along the course of the numerous stream-beds. The water thus accumulated in rocky basins or marshy lagoons, affords the only supply for travellers, over these arid wastes. During the dry season these plains spread out their dreary tracts, unrelieved by a single feature of fertility, occupied by innutricious grasses or a scattered growth of dry shrubbery, among which the repulsive form of the "*Spanish bayonet*" (*Yuca*) is a conspicuous feature. Owing to their exposed and elevated position, these plains are subject to great extremes of temperature. They are mostly shut off from the Rio Grande by a variable mountain range, composed of the carboniferous limestone, variously associated with igneous rocks. The passage to the valley is accomplished by following down the natural cleft made by some rain stream. These passes exhibit fine sectional views of the tilted limestone strata, exposed in various conditions of disturbance, in some places inclined at an angle of 80° to the west, and at other points exhibiting evidences of igneous action in metamorphic changes.



Eagle Springs.

We have thus reached, on the line of the ordinary wagon-road, the upper valley of the Rio Grande, the external features of which, as more directly connected with the line of boundary, will claim a more detailed notice. At first, however, a more rapid sketch must suffice, while continuing to notice the general features of scenery and geological structure presented on the route westward to the lower valley of the Rio Gila.

As we pass from the rocky cañon, by which we enter on the Rio Grande valley, we first come upon a gravelly plain, generally presenting a smooth and more or less uniform surface, sloping gently toward the main bed of the valley. This plain, in receiving the drainage from the adjoining mountain ranges, is variously cut up by deeply-trenched arroyos, and terminates on the alluvial tracts below in gravelly bluffs of variable height.

This table-land is encountered wherever the course of the Rio Grande is not hemmed in by precipitous rocky cliffs, and is seen forming a belt of variable width on both sides of the river, extending to the base of the adjoining mountains. In all these situations it presents very uniform features.

An obvious analogy will be at once perceived between the latter formation and the wide-spreading upland alluvial plains, before noticed; in fact, a direct continuous connexion between them may be often traced. They evidently belong to the same general formation, representing basins filled up with alluvial and diluvial depositions, concealing, it may be, older tertiary strata below.

The pebbles contained in this formation can readily be traced to their original sources in the adjoining mountains, being of larger size and more angular near the base of the mountains, and smaller and more rounded at a greater distance. The earthy medium is generally a coarse sand or fine marl, argillaceous matter being less frequent. Occasionally the exposed bluffs show deposits of gypsum, which in some localities forms extensive beds. The most usual form of this material is in confused crystalline and fibrous masses, imbedded in loose marl. At other places a calcareous chalklike deposition is met with, occupying usually the upper stratum of the table-land.

A general *saline* character, pertaining to this formation, is also evidenced in the growth of saline plants or direct salt efflorescence in the lower depressions of valleys.

SECTION OF EARTHY TABLE-LAND FORMING THE BLUFFS OF THE RIO BRAVO ABOVE EL PASO, CORRESPONDING WITH THAT FORMING THE "JORNADA DEL MUERTO," TO THE NORTH.

A. Highly calcareous marl, chalklike, with occasional pebbles.
B. Brownish gray sand, with nodules of clay.
C. Yellow ferruginous marl.
D. Debris of drifted sand and washed clay.

As seen from any high mountain elevation, this table-land sweeps with all the exactness of a sheet of water, encircling as with a shore-line the bases of distant mountains, frequently completely insulating peaks and ridges, and everywhere masking the true connexion of the various formations.

The progress of subsequent drainage is also plainly seen in the various terraced elevations which this table-land assumes. It may further be observed, briefly, that this is the formation that stamps the character of sterility on so large a scope of country forming those desert tracts known as "*Jornadas,*" of which the "*Jornada del Muerto*" is a noted example. It is to this character of country, moreover, properly belongs the Spanish term "*Llano Estacado,*" or *Staked Plain*, a term which has been less appropriately applied by travellers to the cretaceous table-lands of Texas, before noticed.

The proper alluvial tracts of the Rio Grande, as here met with on our route, exhibit a belt of variable width, from a mere narrow strip to several miles in breadth. Its lower portions are marked by frequent sloughs and old river beds. The body of the soil is sandy, but acquires a somewhat compact texture from the deposition of river slime, and is further enriched by the decaying vegetation that luxuriates on its moist bottoms.

The desert table-land is constantly encroaching on this alluvial belt, in the washing of its numerous stream beds, or the finest sand wafted by the winds. The roads occupying the river bottom are usually heavy, and whenever practicable are gladly exchanged by the traveller for the compact table-land.

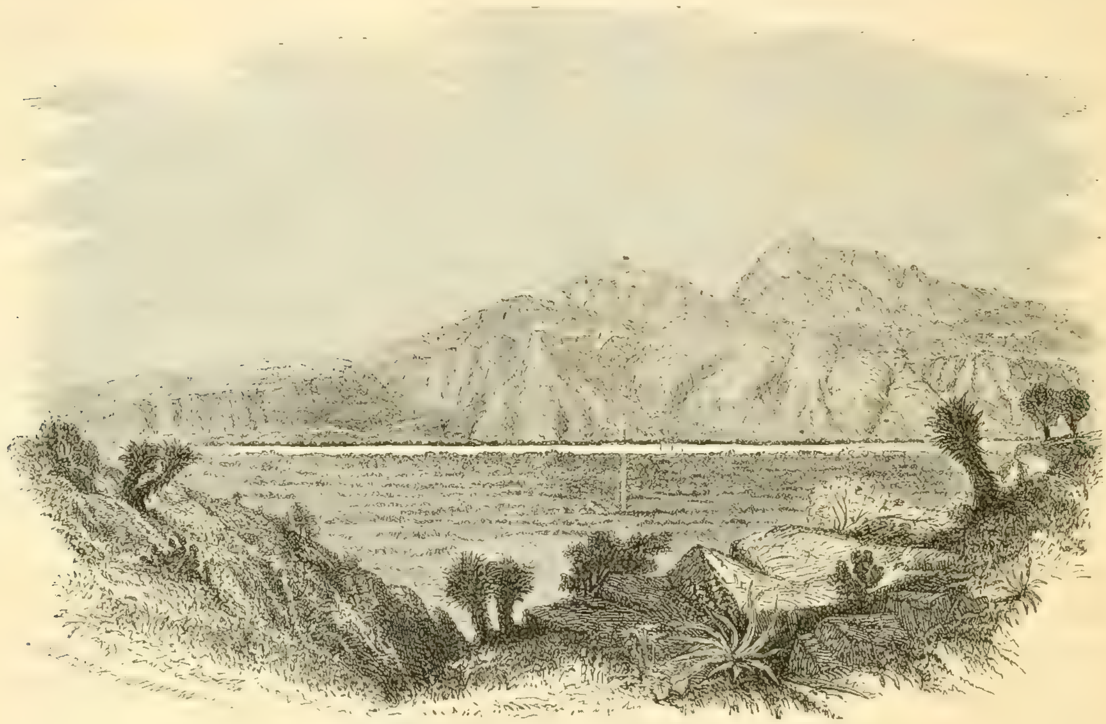
The river itself presents few features of attraction. Its turbid waters sweep along during the flood season, in June and July, a swollen tide, spreading its enriching sediment through the various sloughs and lagoons that line its course, often cutting off all approach by land to the main channel. During low water, which includes the greater part of the year, the river contracts its dimensions, running in a very variable channel, over sandy shoals, interrupted by numerous islands and exposed sand-bars. Occasionally, in very dry seasons, it ceases to run altogether, and stands in stagnant pools.

The portion of the river bottom at present under cultivation in connexion with the El Paso settlements includes a large basin lying south of the El Paso mountains. In this is comprised the large alluvial tract known as "*The Island,*" which is 30 miles in length by 2 to 5 in breadth. This island lies on the American side of the main channel, being separated from the adjoining land by an old river bed, which, except in very low water, still carries a variable stream. The bifurcation of these two arms of the river at the head of the island is taken advantage of to direct a stream of irrigating water through the centre of this tract of land, extending nearly its whole length, and furnishing from its main trunk side branches to supply the cultivated fields. Thus in usual seasons a sufficient supply of water is obtained to meet the wants of ordinary cultivation. At times, however, low water in the main channel is a certain precursor of drought; while at other times an unwonted abundance exposes to the danger of floods.

On the main banks of the river, including the Mexican town of El Paso, and Franklin, on the American side, these inconveniences are measurably obviated by drawing the irrigating supply from a higher source. This is accomplished by the construction of an artificial dam, located some two miles above these respective towns, thus allowing the construction of water-gates and waste-weirs to regulate the supply of water according to need.

Hitherto we have observed the Rio Grande in its character of a variable stream, bordered by alluvial bottoms frequently of considerable width and extent; these again everywhere limited by gravelly table-land, sloping upward to the bases of distant mountains. A short distance above El Paso a new feature presents itself, and we have the mountains themselves encroaching directly on the bed of the river, which here passes in a contracted channel between rocky walls.

The rock exposures on the river bank exhibit disturbed strata of limestone, characterized by frequent fossils as belonging to the *Cretaceous* period. A greater or less metamorphism of this or a more ancient sedimentary rock is also exhibited, while on either side of the river tower up to a height of 500 to 1,000 feet rugged igneous rocks, having a granitic texture, and characterized by Professor Hall as "feldspathic or granitic lava." (No. 40.)



View of the Initial Point, on Rio Bravo.

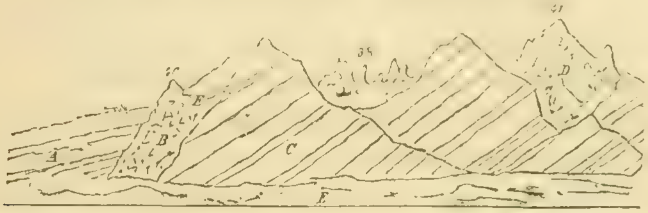
On the Mexican side, the various formations, stratified and igneous, are blended and intermixed in great confusion, the connexion between the various formations being obscured by the irregular exposure of igneous products, the greater or less degree of metamorphism of adjoining sedimentary rocks, and the presence of extensive diluvial deposits. The general surface is thus rendered extremely rugged and broken, the traversed roads being obliged to make a considerable detour from the course of the river.

On the American side is conspicuous a high mountain range, nearly parallel to the river, at a variable distance of from 3 to 10 miles, and observing a regular north and south course. This range is seen to be composed of stratified limestone, dipping very uniformly at an angle of 45° W.S.W., or toward the river; in the face of this dip rest the various igneous outbursts, associated with the disturbed cretaceous beds. This limestone is determined by Professor Hall to belong to the carboniferous series, being a northern continuation of that before noticed at Eagle Springs.

The remarkable character of the stratification is conspicuous at a great distance, its deep gullies presenting fine sectional views, and the different exposures of its sloping surface exhibiting variously curved lines, as the strata are thus brought to view by the action of the denuding forces.

The highest summit of this range presents a sharp, jagged crest, such as might readily be mistaken at a distant side view for an igneous formation. Connected with this upper crest, we also notice outweathering masses of siliceous rock, (No. 38;) these frequently assume grotesque forms and positions, representing various tower-shaped prominences.

MOUNTAINS EAST OF RIO BRAVO SEEN FROM EL PASO.



A. Cretaceous rocks resting on granite, and diping at an angle of 10–15°.
B. Granite.
C. Carboniferous limestone.
D. Porphyry peak.
E. Drift.

At another point this mountain range is interrupted in its usual stratified character by the presence of a porphyritic exposure, (specimen rock No. 41,) forming a dyke, passing through the entire ridge from east to west, and constituting the highest point in this range.

This igneous mass is variously associated with the adjoining limestone strata, lying either above or below, without showing any local variation of the ordinary dip, or exhibiting metamorphic changes at the point of junction.

On its eastern aspect, this range exhibits a precipitous slope, revealing the thickness of the formation in the regular succession of the uplifted strata, as thus exposed, from summit to base; there is developed at several points a thickness of not less than 1,500 feet. No very marked change is observable in the character of the rock from above downwards, or any local evidence of a change of formation.

We have, however, evidence from erratic fossils of the presence of a lower order of rocks, belonging to the *Silurian* period, in this vicinity. Such a formation has been assigned to a corresponding location west of El Paso, by Wislizenus, and there is little doubt but a careful examination along the lower line of these uplifted strata would bring to light this lower class of rocks.

This range continues to the north, forming the Organ mountains, at which point these stratified rocks give place to various forms of igneous products, as indicated in rock specimens Nos. 42 to 46, inclusive.

About seven miles north of El Paso, the mountains adjoining the river give place to the more usual character of gravelly table-land and alluvial bottoms, as noticed below. The table-land is here seen swelling to its broadest dimensions, encircling the distant mountains in every direction, and stretches northward to form the dreaded "*Jornada del Muerto;*" thence sweeping round the northern point of the Organ mountains, it constitutes the extensive desert tract between the Rio Grande and the Sacramento mountains. To the west the same formation is seen, variously interrupted by mountain ranges and isolated points of igneous rock, extending to the base of the Sierra Madre.

In further continuation of our general sketch of external and geological features of country, we now take up the line of march westward, leaving the valley of the Rio Grande at El Paso, to follow out the most southern line of emigrant travel to the lower valley of the Gila river.

On leaving the alluvial basin, in which El Paso is situated, we first ascend over a lower step in the gravelly table-land, sloping gradually upwards, and presenting all the characters of scenery before described. We pass mountain spurs on the right and left, composed of the limestone rock, similar in appearance to the range noticed on the American side of the river, and having the same general dip to the southwest, but at a smaller angle.

Our route, following at first the regular Chihuahua road, passes nearly due south; in about 15 miles from the river we reach a second terraced elevation of the table-land, rising as a steep bluff 80 to 100 feet above the lower step over which we have been passing. The character of this higher deposit is here plainly exhibited in the face of the cliff, consisting of alternate layers of yellow ferruginous marl and coarse brown sand, capped with a thin layer of highly calcareous marl.

From the summit of this second elevation stretches a wide table plain, variously indented by shallow valleys, and swelling toward the base of the mountain ranges. On approaching the line of mountains lying to the southeast, we pass over a spur of limestone rock, connected with this range, showing a dip of 15° to the northeast, a similar inclination being apparent in the principal range. The rock formation appears to be identical with that before noticed near El Paso, having a directly opposite dip, thus forming a synclinal axis, in the trough of which our route seems to have been marked out. Leaving this latter range to some distance on our left, we approach a long serrated ridge of mountains lying directly in our course; near the base of the southeastern extremity of these mountains, occurs the first permanent water since leaving the Rio Grande, about 32 miles distance. This locality is the "Samalayurca Spring."

A short distance beyond this, commences the singular formation known as the "*Medanos*," or *Sand-hills*. They here rise conspicuously to view from the plain below, presenting an exact appearance of the sandy dunes along a stormy seacoast. It is difficult, at first sight, to disconnect this remarkable formation from such an obvious cause, and not to represent it as the sandy beach of the extensive lake in which the deposits were made, forming the wide expanse of table-land so often referred to. The present facts, however, do not warrant such an exclusive opinion; thus the separate grains of sand composing the sand-hills are seen under a lens to be angular, and not rounded, as would be the case in regular beach deposits; they are also extremely light and penetrating, of which every traveller who has occasion to pass this locality in a dry, windy day will have *ocular* demonstration. In fact, the peculiar features of this formation are sufficiently explained in the topographical arrangement of the country, which presents an immense plain, stretching out in the direction of the prevalent northwest winds.

In overlooking the surrounding country from the projecting point of the adjacent gneiss range, these sand-hills are seen to form a crescent, with its concavity toward the northwest, and rising highest where the accumulated deposit is most sheltered by rocky barriers, from the levelling influence of winds, other than those from the northwest.

The spring which occurs in this locality near the base of these sand-hills occupies a natural depression of the general plain. Its issue spreads in a shallow pool surrounded by aquatic plants and shrubbery. The central spring source forms a deep hole, about two feet in diameter, bedded with quicksand, which is surges up intermittently at various points. The temperature of the water is 70° Fahrenheit.

On entering the sand-hills from the north, we first pass over a considerable swell of limestone rock, from the southern slope of which we pass at once into the hills of sand. Its surface, at first variously scattered with arid shrubbery, becomes as we proceed almost pure drifting sand, blown by the wind into varying ripple-marks, and assuming all the different shapes of drift and hollow imaginable. As the view of the surrounding country becomes shut out, there is presented an exact picture of the sandy dunes on an exposed seacoast, and it seems almost strange not to hear the roaring of the surf, or catch a view from the highest elevations of a wide ocean expanse.

The greatest height of this formation is on the southern side, or in the convexity of the arch, which terminates with a somewhat abrupt face, merging into the shrubby plain below.

Our route from this point leaves the Chihuahua road, passing more to the west, and thence skirting along the base of jagged mountains, forming a broken range to the south and southwest. The plain traversed is similar in character, and continuous with that on the opposite side of the sand-hills, having, however, an increased elevation. Our route, bearing S.S.W., is interrupted by occasional spurs of limestone rock, proceeding from the adjoining mountains to the south.

This character continues for some twenty miles, when we begin to notice an obvious change in the external features of the country. The frequent valleys leading from the broken mountain range on our left acquire a more fertile character, and, being removed from the incursions of drifting sand, support a richer growth of plants. Beyond this, the country spreads into wide basin plains, presenting to the eye an uniformly smooth outline. The soil is composed of a stiff clay sediment, and is occupied exclusively with a growth of coarse grasses. In their lower depressions these extended plains frequently present a perfectly bare surface, destitute of all vegetation, the retentive soil either holding the product of recent rains in wide, shallow pools, or more often showing a surface cracked and blistered under the influence of an arid atmosphere. We find frequently scattered over its surface recent land shells, as indications of its lacustrine character. In certain localities these lower depressed flats are covered with a white saline efflorescence, resembling at a distance sheets of water, to the frequent disappointment of the thirsty traveller. The roads leading over these tracts are firm and excellent. The natural supplies of water are very inconstant, being in great measure dependent on rains.

Our road hence, for a long distance, traverses a succession of these plains, of greater or less extent, alternating with short ridges, occasioned by the passage of an irregular mountain range.

These ridges present along their line of elevation various depressions, at which the passage is generally accomplished by an easy gravelly slope. The exposed rocks are of carboniferous limestone, associated with various igneous products.

This character of country continues till we reach the first flowing stream yet encountered on our march from the Rio Grande; this is the *Rio Sta. Maria.* As here exhibited, it shows a flowing brook of limpid water, from 10 to 20 feet in width; at the crossing knee-deep, and flowing over a pebbly bed. Its source lies far to the south, in the State of Chihuahua; thence flowing north, it empties, about 30 miles from our place of crossing, into Lake Sta. Maria. This lake is shown, by the examination of the boundary commission, to be in close proximity to the larger Lake Guzman, from which it is separated by a range of mountains.

These lakes, though thus separated, belong to the same general basin, receiving the drainage of a large tract of country—the San Miguel and its tributaries entering on the north, and the

Sta. Maria on the south. The waters of these lakes having no outlet, are strongly impregnated with saline substances, so as to be unfit for drinking.

The adjoining mountains on our route are of igneous character, being composed of vesicular and amygdaloid trap, forming more or less continuous ridges, ranging north and south.

Associated with the fact of running water in this region, we see the country characterized by an unwonted appearance of fertility and verdure, not alone confined to the immediate borders of the stream, but extending over the hills and plains adjoining.

Our route, after crossing the Sta. Maria river, takes a course S. 70° W., (mag.,) passing over country characterized as above, bounded by mountain ridges of less height above the general surface than those before passed. The greatest development of mountain range lies to the west. The various rock exposures exhibit most abundantly forms of amygdaloid trap ; more rarely we meet with local exposures of limestone strata, or variable metamorphic products.

Conspicuously in view in our direct course are the mountains in which the silver mines of Corralitas are located, consisting of an assemblage of rounded and peaked summits of various heights, rising from 500 to 1,500 feet above the adjoining plain.

These mountains occupy an area of about 5 miles in length from north to south, and 2 to 3 miles in width. They rise isolated in the midst of a broad alluvial plain, sloping gradually on the east and west towards the respective valleys of the Sta. Maria and Corralitas rivers. A wide intervening depression also separates them from higher mountain ranges north and south. The latter mountains present a marked contrast in their precipitous sides and exposed rock of a basaltic character to the uniform smooth outline of the mineral-producing mountains. In these latter, indeed, the geological formation is everywhere concealed from view by a variable deposite of earth and gravel, thickly covered with a growth of grass. It is this fact which has probably given to these mines their Spanish appellation of "*Minas del mineral de la Escondida*," or hidden mines.

The mines at present worked occupy the most northern point of the mountains, though mineral indications and abandoned excavations are common over the exposed face of the whole mountain range. The various excavations bring to view a very uniform character of formation, first passing through a variable layer composed of angular fragments of rock, imbedded in a dry brown earthy medium. The superficial rock exhibits a siliceous limestone of very close compact texture and dark blue color ; to this succeeds the true silver-bearing rock, being a form of subcrystalline limestone showing the action of internal heat, of a much softer texture than the preceding, and of a whitish gray color, (specimen rock, No. 99.)

In this latter rock are exposed the veins of argentiferous galena, frequently extending into the upper siliceous rock, but acquiring its greatest thickness and richness in this lower formation.

The veins of mineral penetrate this rock in the form of variable sheets, dipping regularly at an angle of 45° to the northwest.

Further details in reference to the character and working of these mines, with such reliable mining statistics as could be procured, will be found under a separate head.

From the mines, by a gradual and continuous descent over a wide grassy plain, scattered with low mezquite bushes, we have in view at the lowest depression the valley of the San Miguel or Corralitas river, and the towns of Baranca and Corralitas. This plain, though usually dry, supports a fine growth of nutricious grasses, and the mezquite bushes, which are scattered over its surface, are the main dependence for the necessary supply of charcoal for smelting operations. To first view, this would seem to offer but a poor supply of this needful article, showing in such situations only a shrubby growth; but owing to a remarkable peculiarity of this variable and wide-spread shrub, it is found that, when growing in such exposed situations, instead of developing a distinct trunk, it forms thick underground stems. These being grubbed up by a class of peon laborers, are disposed in piles to dry, when they become fit for conversion into a superior article of charcoal.

At a distance of 20 miles over the above described plain we reach the valley of the San Miguel river; on the eastern bank of which, at a distance of three miles apart, lie the towns of Corralitas and Baranca. We here encounter a beautiful limpid stream and a fertile valley. At Corralitas, this river, as seen by us in the month of February, and again in April, 1852, had an average width of 30 feet, and 2 feet in depth, flowing over a sandy or pebbly bed between shallow alluvial banks. The season of high water is said to be in September, corresponding with the close of the rainy season; at which time a large portion of the adjoining bottom-land is overflowed, the greater part of which is susceptible of cultivation. The width of this alluvial belt is variable, being occasionally spread out in low marshy tracts, 3 to 5 miles wide; at other places contracted by the encroachment of mountains on either side. Some 16 miles above Baranca, to the south, are the remains of ancient and extensive structures, known as "Casas Grandes," still occupied by a flourishing agricultural settlement under the same name. A similar character of mountain ranges, as before noticed, bound the valley on either side; being, however, composed exclusively of igneous rock, the higher peaks showing generally a basaltic structure. The towns of Corralitas and Baranca are built up exclusively with a view to mining operations, the ore being transported to these places for smelting and refining. Living in a state of constant warfare with hostile Indians, the raising of cattle, or even the cultivation of the soil, is confined to a bare supply of necessaries. Abandoned fields and deserted ranchos are frequently met with, showing a quite recent period of greater prosperity, the decline of which is most evidently due, not to the natural incapacity of the country, but the inefficiency and degeneracy of its population.

In a direction W.N.W. from Corralitas, and about 24 miles distant, is the town of Janos. Our road to this place, after crossing the Corralitas river, leads at first over the wide grassy bottom-land of its western side, here nearly 5 miles in width. From this we pass over a ridge projecting into the valley below, and descend again on its opposite slope, following near the course of the lower valley, and passing over a shrubby plain similar to that before described, forming a sort of table-land gradually sloping toward the river. The town of Ianos is situated on a branch of this main stream flowing from the southwest. On reaching the banks of this latter stream, we find a mere rippling brook running over a pebbly bed. A short distance below, its waters are drawn off for the purpose of irrigating the gardens and cultivated fields which occupy the delta formed at the point of junction of the Janos branch with the San Miguel river. The town is situated on the gravelly table-land on the left side of the stream overlooking the river bottom, and set off in the background by a range of high mountains shutting out the view westward. Our route leads directly toward this western mountain range, which is crossed at a low depression, thence descending into still another wide basin plain, extending in its greatest length from north to south, and bounded on the west by the clearly defined range of the Sierra Madre.

The course we travelled thence lies W.N.W., inclining towards this mountain range, and crossing diagonally the wide basin plain intervening between this and the Janos range of mountains.

About 10 miles from Janos we come upon a singular depressed valley, sunk some 50 feet below the gravelly plain, having a lower alluvial belt about a quarter of a mile in width, which is coursed by a limpid brook, and bordered by a scattering timber growth.

This stream is said to have a lagoon source some three miles to the southwest; thence flowing northeast 10 or 15 miles, it terminates in a marshy lake surrounded by mountains; thus showing a character similar to that before noticed in reference to Lake Guzman and Sta. Maria on a smaller scale.

From this point, following a continuous course W.N.W. (mag.,) the road passes over a gently undulating swell, composed of gravelly table-land, thence crossing a wide, open, alluvial basin, similar in character to those before described.

We then approach the high mountain range of San Luis. Our progress toward the mountain base leads by a gradual ascent till a near approach brings to view deep gullied stream beds, connected with the drainage of the mountain valleys, and terminating on the alluvial plains below. Near their sources in the mountains these ravines contain running water, more or less copious, according to the character of the season.

On reaching the first rocky spurs from the main range, the country assumes a most picturesque character. Clumps of *live oak* (*Quercus Emoryi*) edge the ravines, and are scattered along the mountain slopes. Cedar of a shrubby growth is also frequent, and the usual mountain shrubbery serves to give a character of freshness and verdure to the scenery.

Directly at the mountain base, and forming its projecting spurs, a reddish form of porphyritic basalt makes its appearance, showing a precipitous columned face and tabled summit.

In the recesses of the ravines, as exposed by the mountain torrents, a variable deposite of igneous conglomerate is met with, flanking the central rocky mass. This central nucleus, as exhibited along the sides and summit of the mountain range, is an igneous volcanic product of quite recent origin, and characterized by Professor Hall as "feldspathic lava," exhibiting a granitic appearance. (No. 86.)

At the point where the old road crosses the ridge, called the "San Luis Pass," the ascent is quite abrupt, rising from the plain below 800 to 1,000 feet.

The summit crest commands a most extensive and grand view. Looking eastward, the eye takes in at a glance the wide alluvial plain over which we have been passing, encircled by its irregular mountain boundaries, showing plainly its basin character, and in which here and there stand out isolated mountains, as islands in the broad expanse.*

To the north and south is a continuation of the main ridge, more broken to the north, and apparently forming slopes of easier ascent than the one passed over by us. Quite possibly at several places there may be an easy transition from the plains on one side to those of the opposite slope. To the south the range is more continuous, of a rugged character, and increased height.

* This description was written before the line under the treaty of 1853 was run. It will have been seen in the preceding part of this work that good passes were found to the north and within the limits of the United States. W. H. E.

Westward we look down on another alluvial plain, less distinctly bounded by mountain ranges, and extending to a great distance from north to south. On its western limits, at a distance of about ten miles, this plain abruptly terminates by a slightly elevated terrace, the descent from which to the lower level of the San Bernardino valley forms the well known Pass of Guadaloupe.

Here, then, we have the means of estimating the true character of this great water-shed, in its connexion with the present line of boundary both to the north and south.

Considerable confusion has arisen from the vague terms and expressions employed by writers to describe the peculiarities of this part of the central axis of the North American continent. There has been wanting in their popular descriptions the elements of a general principle, applicable alike to all great dividing ridges. Geological science alone furnishes this element, giving, in the general result of its observations, the best means of elucidating all the points involved, and clearly explaining the several local peculiarities exhibited.

In most of the descriptions hitherto given of this portion of the dividing ridge, we hear in frequent use the stereotype expressions that at or near the point under examination the range of the Rocky mountains becomes "suddenly depressed," or "flattened out," to form the great Mexican plateau. Again, that at some imaginary point south of this great change of topographical features rises another distinct range, called the *Sierra Madre*, continuing thence to form the line of cordilleras extending to the extreme of the continent.

Now, such descriptions as these embody no clearly defined principle of geological science, and contain, moreover, errors of fact.

The Spanish name of *Sierra Madre* (literally *mother mountains*) is the general term in use to describe what is called a *dividing ridge* with us, and its special application to the range under consideration is due to the important character of this divide as the *mother range* of the continent.

Now, it is well known that all extended continental ranges are due to a line of internal disturbance, of varying intensity at different points, but in all alike characterized by the protrusion of various igneous products, together with the uplifting of adjacent stratified deposites, either altered in texture by the action of internal heat giving rise to the various metamorphic products, or showing the action of an uplifting force only in changes of inclinatian or dip of the strata.

Most naturally, then, in view of the numerous and varied agencies at work, should we expect changes of character at different points of the same range, corresponding to points of greater or less intensity of the internal disturbance, or the different products erupted or exposed to alteration. Hence occur elevations and depressions, and variety of formation in the course of the same continued range.

With this principle in view, we have a ready explanation of all the peculiarities exhibited in the portion of the range under examination.

Thus the igneous products are mostly of modern origin, exhibiting various volcanic products in the form of granitic lavas, porphyritic basalts, and amygdaloid traps. These products show a very variable character of exposure, forming ranges irregular in their direction, and differing in composition.

These several mountain ranges cover more or less the entire face of the country, including the dividing ridge only as one member of the general series.

The natural explanatory inference from these facts is, that the internal force, here represented in the continued mountain range, was diffused over a large space, and not centralized on one particular line. Hence arises no great prominence of one central chain, but a number of independent ranges, serving to equalize the general elevation and give the character of an elevated plateau to the surface of the country.

Again, the same irregular action of the internal force, and especially the preponderance of recent eruptive products, favors a varied direction of the mountain ranges, by means of which areas are circumscribed and basins formed for the reception of aqueous depositions. Here, then, we see the origin of those extensive plains and stretches of table-land to which our attention has been so frequently directed in the preceding sketch.

These same characters probably apply more or less closely to many other localities connected with the general dividing range, whether north or south of the point we are examining.

We are now prepared to descend the western slope of this dividing ridge, and note the peculiarities of feature presented on our route westward.

Decending, then, by an equally steep slope as the eastern ascent, and about the same height, we come upon the alluvial plain below. The lowest depression of this plain is composed of a light alluvial soil, and thence sloping gently upward to the west, exhibits a gravelly deposit, till, at a distance of about eight miles from the base of the mountain just left, we come upon the abrupt descent of the Guadalupe Pass.

This noted pass, which has been so frequently traversed on the line of emigrant travel to California, is now so well known as hardly to need a detailed description.

This pass has been properly characterized as the first step of considerable descent from the Mexican plateau to the heads of valleys leading to the Californian gulf. It has now been clearly established that at a point farther to the north, near the parallel of 32° latitude, the descent westward may be accomplished by a more gradual slope, and without leaving the basin of drainage pertaining to the Gila river.

The geological structure exposed in this mountain pass is similar to that before noted as occurring in the upper slope of the Sierra Madre, including feldspathic lava, granitic in texture, associated with basalt, stratified porphyry, and closely cemented breccias.

These several forms, variously associated, serve to give a remarkable diversity and broken character to the rock exposure, presenting a confused outline of mingled crests, peaks, and ravines. Through these the road has to work its way by sharp turns and very steep descents. On attaining a lower level we pass down a ravine, gradually widening, which finally spreads into a small valley, watered by a fine running stream, and beautifully shaded by large sycamore and cotton-wood trees. This valley is closely hemmed in by steep rocky walls, marked by intricate ravines, and rendered picturesque by a varied assemblage of *live oak*, *cedar*, and other verdant shrubbery. In emerging from the higher points of the mountain range, the walls of this cañon exhibit various forms of stratified porphyry running into a breccia. The character of stratification has, at several points, a close resemblance to altered sedimentary deposits, showing a reddish color and a very uniform character of dip.

We finally leave this valley, mounting up a steep bank, composed of gravelly table-land, rising 200 feet above the bed of the stream, thence passing by a gradual and continuous slope toward the main valley of the San Bernardino. The table-land here has all the usual characters of this formation in other parts, not differing essentially from that of the Rio Bravo or Gila valleys, and terminates by an abrupt bank, bounding the alluvial basin below.

This basin, forming, as it is said, the head of the Yaqui river, here shows a wide flat plain, extending from north to south, and having a breadth of three to five miles. On its western edge is situated the deserted settlement of San Bernardino. Adjoining this rancho are numerous springs, spreading out into rushy ponds, and giving issue to a small stream of running water. The valley is covered thickly with a growth of coarse grass, showing in places a saline character of soil. The timber growth is confined to a few lone cotton-wood trees scattered here and there.

Signs of previous cultivation are limited, this settlement having been engaged principally in stock raising. The numerous bodies of wild cattle now running at large over this section of country are the remains and offspring of domestic herds, now widely scattered and hunted by Indians.

The western side of the valley is precisely similar to its opposite, showing the same general character of gravelly table-land. This leads by a gentle ascent to a low point in the dividing ridge separating the valleys of San Bernardino and Aqua Prieto.

A remarkable tower-shaped peak rises in the centre of this ridge, a short distance south of the road, forming a conspicuous landmark. This ridge is seen to be composed of one or more of the variable forms of volcanic products so often noticed heretofore; the prevailing character is here a reddish brown granitic mass.

The descent on the opposite (western) side of the ridge to the alluvial bed of the Aqua Prieto is over a long, tedious slope, the gravelly table-land giving place to extensive tracts of clay or loam, supporting a patchy growth of coarse grass. The "Black Water" valley, at its lowest depression at this point, contains no constant running stream, its course being mainly occupied with low saline flats or rain-water pools. Extensive lagoons are said to occur in this valley a short distance south of where the road crosses.

The main tributary to this valley comes from the west, and is followed to its head on the line of wagon-road. Its bed consists of a wide ravine, coursing through pebbly strata, variously marked by the washings and drift deposits, caused by the occasional strong current derived from local rains. At other times its bed is entirely dry. The timber growth along its borders consists of hackberry and walnut.

At its source there is a fine spring, issuing from ledges of stratified porphyritic rock, identical in character with that noticed at the foot of the Guadalupe Pass. The stratification is inclined to the northeast, and along the line of its tilted ledges the spring issue forms frequent pools of limpid water.

From this point we pass in a circuitous course to the southwest, winding among rocky spurs, and thence passing up an upland valley, agreeably diversified with groves of live oak and covered with luxuriant and nutritious mountain grasses. On this route we pass gradually to a divide which leads, on its western aspect, to an eastern branch of the Upper San Pedro valley.

The country here begins to assume most attractive features. To the north and west rise high mountain ridges clothed with pine and oak groves; the intervening country is everywhere carpeted with fine grama grass, the nutritious quality of which is exhibited in the well-conditioned character of the numerous wild horses and cattle that luxuriate over this favored region. Water is frequent in the valleys, and everything indicates a capacity for cultivation, the grazing capabilities being unequalled by any tract heretofore passed over.

Beyond this the San Pedro valley spreads out in diverging branches to the east and west, thus drawing tributary a very extended mountain drainage.

It is this latter character which sufficiently accounts for the fact that the San Pedro is the only branch of the Gila River, coming from the south, which furnishes an uninterrupted stream of running water along its whole course.

At the point where the main valley of the San Pedro is reached we find an alluvial belt, variable in width, and occasionally marshy. These bottoms are flanked by terraced table-land of unequal heights, composed of a hard gravelly soil, and supporting a close sward of grama grass, giving a peculiarly smooth shorn look to the general face of the country.

Occasional exposures of igneous rock, or the projecting spur of some mountain ridge, serve to diversify the scene; and quite constantly in the higher branch valleys is exposed a form of igneous conglomerate. This latter formation is exposed in irregular bluffs along the edges of these valleys, presenting washed faces and precipitous walls crowned with terraces. These higher points are frequently set off with the remains of deserted dwellings, plainly located with a view to defence. Other eminences, commanding extensive views, are occupied by rocky breastworks, serving the double purpose of watch-towers and strongholds of retreat. Associated with these are also extensive rocky enclosures, in which the cattle were secured. All these points are suggestive of the condition of constant warfare to which this commencing civilization was subject, and under which it was at last obliged to succumb.

These upland valleys are only sparsely wooded by occasional cotton-wood or walnut trees. As we approach the mountains, however, the timber growth becomes more abundant, and the lower ridges are occupied by extensive groves of oak, which, on the higher points, are associated with pine and cedar.

From the head of the "Nutria" (southwest) branch of the San Pedro, up which our road passes, we commence the steep ascent of the mountain ridge lying between the Santa Cruz and San Pedro valleys. The character of this range is exactly similar to what we have before described as pertaining to all the higher mountains passed over on our route, west of the Sierra Madre.

The height of the pass leading to Santa Cruz is not less than 1,000 feet above the respective valleys on either side, being equally steep and rugged on either slope. The same ridge, extending toward the south and southwest, forms a continuous line of high mountains, lying between the San Pedro and Santa Cruz valleys; the preferable route for crossing is probably that taken by Col. Cooke in 1846.

The upper route, being the one more commonly followed, strikes the Santa Cruz valley near its head source.

The direction of this valley is at first nearly due south, giving the idea that its drainage is on the line of the rivers flowing south to the California Gulf. It is indeed so laid down on most of the maps of this region, but this is manifestly incorrect. About three miles south of the town of Santa Cruz the valley makes a sharp elbow; thence doubling on its former course, it continues north and northwest, being the same valley in which, lower down, are located the towns of Tubac and Tucson; thence leading toward (though probably hardly ever reaching) the Gila River, near the Pimo settlements.

The situation of the town of Santa Cruz is highly picturesque, lying embosomed amid lofty wooded mountains. Its soil is fertile, abundantly watered, and susceptible of easy irrigation; its elevation gives it a cool temperature, suited to the production of northern fruits and cereal grains.

A cut-off, over the mountain range intervening between the two courses of the river, leads, by a distance of 18 miles, to a lower part of the valley, maintaining in the main the same general features, but showing a marked change in the climate. This latter fact becomes still more apparent in our progress downward, as shown by the comparative forwardness of vegetation. Thus a short journey of three days (or 80 miles) from Santa Cruz, between February 27th and March 1st, 1852, showed a difference in the advance of vegetation equal to a full month in time; so that while at Santa Cruz the cotton-wood trees were barely budding, the first day's journey displayed their loose catkins, the second the opening leaf, and the third the full leaf.

Greater aridity also characterizes the lower portion of the valley, and the live oak, so common above, gives place to heavy growths of mezquite. The adjoining mountains on either hand become in great measure bare of trees, and present steep ledges of igneous rock exposed along their broken range. The immediate edges of the valley are flanked by a conglomerate formation, similar to that noticed on the Upper San Pedro. Accompanying these changes the stream contracts, and finally, in certain points along its course, ceases to run, and the usual desert features of all waterless tracts in this region are exhibited.

We thus pass the settlements of Tomocacori, Tubac, San Xavier, and Tucson, together with numerous deserted ranchos occupying various points along the valley. After leaving Tubac, which is situated about midway between Santa Cruz and Tucson, the valley expands into a wide open basin, the mountains receding on either hand, and the dry valley, now almost exclusively occupied by mesquite, is bordered by a wide stretch of gravelly table-land. On this table-land we meet, for the first time on our route, that most remarkable vegetable production, the *Cereus giganteus*. Further on it becomes abundant, its stiff trunks and branched arms rising up here and there like sentinels, and giving a most peculiar character to the landscape scenery.

Approaching the town of San Xavier, noted for its superb church, contrasting strangely with the mud hovels surrounding it, we again come upon running water, with its constantly associated fertility and verdure. In this vicinity occur rocky knolls, composed of a dark-colored trap-rock, which formation becomes still more largely developed in the vicinity of Tucson, forming extensive ridges having a tabulated form and very irregular outline.

The settlement of Tucson occupies the lowest line of constant running water, and consequently the last fertile basin lying in the course of this valley. Below this, on the north, succeeds the extensive desert tract lying between Tucson and the Gila River.

In pursuing our course down the valley, the adjoining table-land gradually merges into the desert plain over which our road passes. Hardly, however, did it seem to deserve the name of a desert at the time of our crossing it. Owing to the refreshing influence of recent rains, a rapid growth of evanescent flowers gave its otherwise barren surface the aspect of a flower garden, regaling both the sense of sight and of smell with a profuse and varied assemblage of tints and scents. Water sufficient for our animals was found in ravines by the side of the road, and a journey of eighty miles, otherwise dreaded, was, by an agreeable disappointment, rendered highly pleasant. Our journey was made in the first week in March ; doubtless another month might have changed its features materially.

Our course lies quite regularly to the northwest, a broken line of mountains lying on our left, while to our right lies the extensive high mountain range northeast of Tucson. Directly in our course is a singular pinnacled peak, being the "half-way point" between Tucson and the Gila ; approaching this, we pass by a gradual ascent over a gentle ridge, forming a depressed point in a continuous mountain range extending from the pinnacled peak, on our left, northeast toward the Gila valley. Near the summit of this ridge we pass small alluvial tracts, then occupied by a luxuriant growth of young grass, and cut up by deep gullies containing abundant supplies of rain water. The rock exposure here has a more ancient appearance than any before passed, indicating an approach to the granite ranges of the Californian Cordilleras.

We descend the northern slope of this ridge, passing over extensive clay flats washed by recent rains into frequent gullies, these finally centering in one form the irregular bed of a rain stream leading direct to the Gila river.

The portion of the Gila valley thus reached is where the river, emerging from the high mountains occupying the mouth of the San Pedro, spreads out into the extensive alluvial bottoms, occupied in part by the settlements of the Pimo and Maricopa Indians.

The gravelly table-land here forms a gentle slope, leading from the distant mountains, and indenting the alluvial belt below. This latter consists of an upper level, supporting a shrubby growth of mezquite, and a lower bottom subject to river overflows. On these upper portions the Indians usually construct their dwellings, thus overlooking the lower cultivated fields. The amount of land here capable of cultivation is quite extensive, forming a belt on each side of the river often several miles in width, and extending east and west for 20 miles or more.

The stream of water, then at its average height, (in early March,) measured about 40 yards in width with an average depth of 2 feet, the volume, however, being considerably diminished by the extensive irrigating ditches drawn from above.

The line of the river bank is at this season set off with lagoons and marshes, and everywhere bordered with a dense willow growth, rendering it difficult of approach.

The dams, which serve the purpose of drawing off the irrigating water, are constructed of old willow trunks and snags; these, in the course of time, entangling the loose soil and sediment borne down by the river, furnish a bed for the willow growth, thus becoming more permanent with age.

From a rock knoll of true granite, abutting on the river on the American side, a fine view is obtained of the general character and external features of this interesting locality.

The character of the Gila valley, from this point down to its mouth, did not come under my personal inspection. All accounts represent a great uniformity of general features already sufficiently detailed.

Thus we have a succession of basins, limited by mountain barriers, through which the river forces its way, forming cañons of greater or less extent.

These basins are again occupied by more or less extensive stretches of gravelly table-land, representing the desert features of this region; through these are marked the alluvial tracts, varying in width and character according to the geological conditions surrounding them; through this the river works its sinuous course, with a swift current and turbid water, till it empties into the Colorado of the West.

IV.—MINERAL PRODUCTIONS OF THE REGION OF COUNTRY, IN CONNEXION WITH THE MEXICAN BOUNDARY LINE, FROM THE MEXICAN GULF COAST TO THE COLORADO OF THE WEST.

[NOTE.—This report was written before the treaty of 1853, and applies more particularly to the old boundary under the treaty of Gaudalupe Hidalgo.]

The mineral productions of the region of country, in connexion with the United States and Mexican boundary line, are necessarily various, as corresponding to the different geological formations. The detailed examinations necessary to furnish a satisfactory estimate of the real value of this class of products are still wanting, and the peculiarities of the country itself place great obstacles in the way of arriving at clear results.

Among the most important, which we may here briefly enumerate, are: *First.* Such as are connected with the various forms of igneous and metamorphic rocks, including *Copper, Gold, Silver. Second.* Such as pertain to the stratified or alluvial deposites, including *Coal, Salt, Gypsum.*

FIRST CLASS.

COPPER is quite frequently found in connexion with porphyritic rocks. The most usual form of the ore is that of *green malachite* and *red oxide.* The locality best known is that of *Santa Rita del Cobre,* which was profitably worked about 20 years ago. Analysis of ore from this locality exhibited a yield of $75\frac{36}{100}$ per cent. of copper.—(See analysis by Professor T. Antisell.)

No mine of copper is at present worked in any part of the region under examination.

GOLD is said to be sparingly found at various localities, in connexion with diluvial deposites, derived from adjacent igneous rocks. It is here met with in a finely disseminated state, and has never yet been found in sufficient quantities to yield a fair return for the labor expended. It would seem here to belong to the same character of formation as that of Mexico, associated with forms of porphyry, and never to approach in richness the deposits of California; such, indeed, we would expect in the general absence of metamorphic slates and quartz veins, so well known to be the most prolific source of gold in other regions. But one locality of the true gold-producing rocks was met with on our route, and that was at the furthest western point, near the Pimo villages, on the Gila.—(Specimen rock, Nos. 97 and 98.)

SILVER.—Silver ore is found at several localities, mostly on the Mexican side of the line. It has also been found in the Organ Mountains and various portions of southern New Mexico. The localities best known in Mexico adjoining the boundary line occur at Corralitas and Presidio del Norte, in the State of Chihuahua, and at Santa Rosa, in the State of Coahuila. The only one at present successfully worked is that at Corralitas, before referred to. The ore from which the silver is obtained is a form of *Argentiferous Galena,* containing very variable proportions of silver. According to the statement of the principal proprietor of these mines, *Mr. Flotte,* the average yield of the best mineral is 0.50 per cent. of silver; analysis of a single specimen by *Professor Antisell* gave only 0.03 of one per cent., a discrepancy difficult to account for, except on the supposition that the ore varies remarkably in the relative amount of contained silver.

The working of these mines is carried on in a very rough manner. The excavations simply commence with the surface exposure of the veins, thence following them down by rude and irregular shafts, inclined according to the dip of the vein, at an angle of 45° to the northwest. The ore is extracted by blasting, both the mineral and the refuse material being brought up on men's backs. Where the depth is such as to cause an accumulation of water the mine is abandoned.

The richest of these distinct mining excavations is that called "*San Pedro.*" This, when visited in 1852, had attained a depth of eighty yards. The mineral vein, as exposed along the line of excavation, exhibited a very variable thickness, from one to twelve inches; the character of the ore and its specific gravity also varied at different points.—(See description and analysis by Professor T. Antisell.)

The mode of extracting the silver is by a double process of *smelting* and *refining.* By the former the ore is reduced, by the means of a common furnace, to the form of an alloy of lead and silver. In the refinery the lead is removed by burning it out in a blast furnace, leaving the silver in the shape of irregular cakes, weighing about eight ounces each. The refining process occupies about twelve hours.

The following information in reference to the working of two of the principal mines and reducing establishments and the amount of silver produced is furnished by the proprietor, *Mr. Luis Flotte, of Baranca.*

The mine of San Pedro employs about forty men, whose wages average $10 per month. The amount of ore extracted by this number of men monthly is from 160 to 200 loads, of 300 pounds each. This is calculated to yield from 24 to 32 ounces of silver per load. The average monthly expense of working this mine is about $1,000.

The mine of Leon employs about the same number of men, and requires the same expense of working, viz: $1,000 per month. The amount of mineral extracted from this mine is about 500 loads per month, of 300 pounds each, estimated to yield three ounces of silver to the load. This ore is chiefly valued as a flux to assist in the reduction of the richer mineral.

Smelting Establishments and Refineries.

There are two of each of these establishments in operation at Baranca. The number of men employed in all the necessary labor, including hauling the mineral, manufacture of charcoal, &c., is 125. The average monthly expense is $2,000.

When in full operation, the amount of ore smelted is 180 loads of San Pedro ore, and 500 loads of Leon mineral, of 300 pounds each. Total, 204,000 pounds per month.

The yield of silver for this amount of ore would be an average of 420 pounds, at $16 per pound, equal to $6,620, leaving a profit for capital invested of $2,620 per month. The total amount of silver produced at this mining location for six years ending January 1, 1852, as given by the two proprietors, is—

Mr. Luis Flotte, at Baranca	$340,000
Señor Don José Maria Zuloaga, at Coralitas	146,000
Total	486,000

Coal.—A remarkable form of coal, closely resembling *cannel coal*, is found in connexion with the cretaceous strata on the Rio Grande, being exposed at several points along the course of the river from the mouth of the Pecos to Laredo. The character of the formation and economic value of the product, as an article of fuel, will be given in the report of Mr. Schott.

Salt occurs in connexion with salt lakes, occupying depressed portions of the wide desert tracts, to which the term of *Llano Estacado* is applied. The product is more or less pure, and in greater or less abundance, according to obvious local causes.

Gypsum occurs in connexion with marls, belonging either to the upper Tertiary, or alluvial series of deposits. In such situations it frequently forms very extensive beds, composing the main bulk of local table-land exposures.

In concluding this report, I have to express my special obligations to Professor James Hall, of Albany, who has kindly favored me with his views of the geological collections of the survey, and otherwise rendered assistance in making out this report. Similar acknowledgments are due to Professor John Torrey, of New York, in reference to the botany.

Especially, in this final conclusion of my duties on the Mexican boundary survey, are my sincere thanks due to Major W. H. Emory, with whom I have been directly associated, in field and office duties, for the last five years, a length of time signalized by repeated and considerate acts of kindness on his part, as my superior officer, and gratefully remembered on mine.

Respectfully submitted.

C. C. PARRY, M. D.,
Botanist and Geologist U. S. B. C.

I consider the present a proper place to insert the analysis of minerals, not only of those referred to by Dr. Parry in the above memoir, but those which were collected in the new Territory subsequently to his withdrawal from the commission.

In the Organ Mountains, near Fort Fillmore, and at several other places along our route, silver mines have been opened by enterprising Americans, but I have not obtained analyses of the minerals procured at them, for the obvious reason that the experience of the miner will be a more valuable test of the value of the mine than any which can be afforded by specimens.

Nothing can be a more fallacious test of the value of a mine than the analysis of pieces of ore taken at random from the metallic vein, as most of these have been. Its true value can only be arrived at by actually working the mine, which, for the purpose of experiment, may be carried on upon a very limited scale.

Those familiar with the localities will see in the analysis that specimens from veins of known value are here exhibited as yielding a very low per cent. of precious metal. These specimens are therefore not fair examples of the whole.

When at Janos, I observed the inhabitants collecting nitre from the soil by the rudest process, and was informed that all the powder used in blasting at the mines of San Pedro was manufactured from the nitre thus obtained. The soil, in many places almost destitute of vegetation, is no doubt surcharged with this substance, and a portion of soil was collected to be analyzed, and has been mislaid. In view of the difficulty experienced in obtaining this substance in time of war, the subject is well worth the attention of government.

Many of the earths and rocks were placed in the hands of my lamented friend and classmate, Professor J. W. Baily, for microscopic examination. His state of health did not permit him to go entirely through with the examination. He, however, had made some progress, and I here give a short and characteristic note from that eminent and beloved gentleman, which gives an interesting summary of the results of his investigations up to that time.

W. H. E.

WEST POINT, N. Y., *April* 2, 1856.

Major W. H. EMORY, *Commissioner U. S. M. Boundary Survey.*

DEAR MAJOR: This time we have some luck. Three of the specimens last sent prove quite interesting. They are Nos. 18 and 19, from cretaceous strata, Leon creek and Leon spring, West Texas, and No. 23, travertin-like crust, from bed of San Pedro

The specimens Nos. 18 and 19 are interesting, as containing a considerable number of fossil Polythalamia, (microscopic calcareous shells,) and still more so from yielding fine *green sand* CASTS of the same minute forms. This fact of the occasional formation of green sand in the cavities of minute shells was discovered by Ehrenberg, and I have verified it in specimens from several American localities. I would be glad to get a good supply of Nos. 18 and 19 for further study.

The travertin-like crust, No. 23, has an organic basis. When treated with chloro-hydric acid, it leaves a spongy mass, greater than the original volume, and composed of plants belonging to the genera Oscillatoria, Hydrocoleum, &c. There are several of these plants which delight in calcareous waters, and always incrust themselves as in the specimens you have sent.

With regard to the moss agates, I cannot satisfy myself that the filamentous mosses in them are really of confervoid origin. If they were, it is now impossible to distinguish a single vegetable cell. I incline to the belief that they are rather concretionary deposits of oxide of iron, which may possibly have had organic nuclei to collect upon; but if so, these last have disappeared.

The cretaceous earths attached to the Texian fossils will be well worth further study, and any which have specks of green sand in them will be particularly interesting.

Yours, very truly,

J. W. BAILEY.

NEW YORK, 13 *Mercer street, January* 31, 1854.

Three samples forwarded for analysis:

No. 1. Silver ore from San Pedro mine.
No. 2. Ore from copper mines.
No. 3. Ore from Leona mines.

No. 1.—Argentiferous galena; partly granular, chiefly fibrous; specific gravity 603. It contains iron pyrites, disseminated in small cavities.

The amount of silver was determined by moist analysis. Two grammes of ore were treated with nitric acid; to the clear solution hydrochloric acid was added—the resulting cloride of silver fused. The lead was determined as carbonate, by adding carbonate of soda to the solution, after separating the silver. Some adhering earthy matters remained undissolved by the nitric acid.

Analysis yielded in 100 parts:

Insoluble silicates	4.50
Lead	82.20
Sulphur	12.79
Oxide of iron and traces of copper	.46
Silver	.03
Loss	.02
	100.00

Indicating a yield of $6\frac{1}{4}$ ounces of silver per ton.

No. 2. *Red copper ore.*—Massive; specific gravity 5.10; of a deep liver red color in fresh fractures, coated on the outside with a crust of green malachite, to the depth of $\frac{1}{10}$ of an inch; dissolved with slight effervescence in nitric acid; it furnishes water when heated in the test-tube, arising from the presence of the hydrated carbonate. The copper was determined as oxide by treating the acid solution with caustic potass.

In 100 parts:

Water and carbonic acid	4.70
Oxide of copper	95.30
	100.00

or yielding $75\frac{36}{100}$ per cent. of copper.

No. 3. *Brown iron ore.*—Ochreous variety; specific gravity = 3; yields but little water in the tube; effervesces slightly in hydrochloric acid. The iron was determined as peroxide by precipitation with ammonia.

In 100 parts:

Organic (vegetable) matter and water	7.80
Insoluble earthy matter, (clay)	15.00
Peroxide of iron	70.70
Lime	5.05
Magnesia, Carbonic acid	1.00
	100.00

Yields 49 per cent. of metallic iron.

THOMAS ANTISELL, *M.D.*

Smithsonian Institution, *Washington, March* 1, 1856.

Sir: I have the honor herewith to submit to you the results of the examination of salts, ores, and minerals, made by me for the United States Mexican Boundary Commission. The analyses were made in the laboratory of this institution. The numbers correspond with those attached to the original labels. The ores, though few in number, are of such a character as to raise high expectations of the mineral wealth which thorough exploration will develope in the region traversed by the commission.

No. 15. Argentiferous galena, from the copper mines of Santa Rita, in New Mexico. The specimens examined are very fine-grained galena, containing scattered particles and nodules of iron and copper pyrites, with some oxide of iron, resulting from the oxidation of iron pyrites. One of the specimens contains adherent portions of the gangue from both sides of the vein, showing it to have been, at this spot, 1 to 1½ inch in thickness. It yielded 73.75 per cent. of lead. The mean of two accordant assays, by cupellation, gave 0.365 per cent. of silver. The copper in both this and the following specimen is so unequally disseminated, that it was impossible to obtain a fair average without destroying the specimen. The amount of copper in both ores is small.

No. 16. Lead ore, from the silver mines of San Pedro, in Chihuahua. The specimens furnished me do not, probably, represent fairly the richness of the mine. They are very unequal in composition and value, consisting of galena, mixed with zinc blende, quartz, iron pyrites, and a little copper pyrites. A sample, which was regarded as affording a tolerably fair average, yielded 28.29 per cent. of lead. The mean of two assays gave 0.70 per cent. of silver.

No. 18. A white saline substance, occurring as an incrustation on the soil, at Salado spring, in Chihuahua. It dissolves in water, leaving only a small residue of white sand, containing calcareous particles. It consists chiefly of chloride of sodium, (common salt,) with a considerable quantity of sulphate of soda, and small quantities of sulphate of magnesia, chloride of magnesium, and sulphate of lime. The presence of nitrates could not be detected. If this salt occurs in sufficient quantities, it will prove a very valuable source of supply of table salt, the want of which is strongly felt in this region. The presence of sulphates of soda and magnesia renders it unfit for use in its present state, but it might easily be freed from these impurities by solution and re-evaporation. The sulphate of lime is precipitated, in combination with sulphate of soda, as pan-stone, when the saline solution attains a certain degree of concentration. If the concentration be not carried too far, chloride of sodium crystallizes out almost pure. The mother liquor contains in solution the rest of the chloride of sodium, with sulphate of soda and salts of magnesia. It is highly probable that the springs which deposit this salt, by natural evaporation, contain, in solution, enough salt to be used as salines. The waters might be concentrated to a greater degree by being made to pass over piles of twigs, in graduation houses, as is commonly done in Germany. A great saving of fuel is thus effected. Analyses of the mineral waters of this country would probably lead to many important economic applications.

No. 18. Is merely the same salt as the last specimen, taken from a depth of six inches below the surface. The proportion of sand and gravel in it is much greater, but it shows that the whole soil is impregnated with saline matters.

No. 19. Copper ore, from Boca Grande, in Chihuahua. This is a very beautiful and pure specimen of red oxide of copper, intimately mixed with native copper. It is entirely free from sulphurets and earthy minerals. The exterior is partially covered with a thin crust of malachite—green carbonate of copper. This ore yielded, in an assay conducted in the moist way, 94.8 per cent. of copper. A very similar ore has been described by Mr. Blake, as occurring near Altar, in Sonora.* The compact subcrystalline appearance of this ore gives evidence of a massive deposit.

* United States Pacific Railroad Survey, (partial route in California,) under the command of Lieut. R. S. Williamson, Top. Eng., 1853. Preliminary report by William P. Blake, geologist and mineralogist, p. 75.

No. 23. A compact, white, feldspathic rock, from the valley of the San Pedro river, in Sonora. Before the blow-pipe it exhibits all the reactions of a felsite or fine-grained porphyry. The texture is compact, resembling the base of porphyry without the crystals. The surface exhibits numerous small cavities, resulting, perhaps, from the decomposition of crystals of feldspar.

No. 24. A yellowish pulverulent substance, described by Dr. C. B. R. Kennerly as occurring in a mountain gorge between abrupt walls of volcanic rock. When treated with acid it effervesces strongly, showing the presence of carbonate of lime. After the effervescence has ceased, the residue does not seem to be much acted upon by hot concentrated acids. Before the blow-pipe it fuses with difficulty to a white enamel, owing probably to a combination, at this high temperature, of the silica and lime present. Water takes up from it a considerable quantity of saline matters, consisting of sulphates of lime and magnesia, with traces of chloride of sodium and chloride of potassium. If this be a volcanic ash, as its appearance and mode of occurrence suggest, the presence of the saline matter and carbonate of lime must be attributed to the subsequent action of mineral, probably thermal, springs containing these salts in solution.

Very respectfully, yours,

JOHN D. EASTER,
Ph. D., Chemist and Mineralogist.

SMITHSONIAN INSTITUTION, *Washington, April* 11, 1856.

SIR: I have the honor herewith to report the result of my examination of the ores and coals submitted to me for analysis. Those the locality of which is not given belong to the collection obtained by you from a "prospecter," who refused to reveal the precise locality in which they were found. The rest were collected by Mr. A. Schott.

No. 1 is a lignite taken from cretaceous strata, covered by trap, at Santa Rosa, Coahuila. The specimen has a brilliant lustre, even fracture, and shows no trace of woody structure. The streak is brown. It is free from pyrites. Fragments of it heated to redness in a closely covered crucible lost 30.45 per cent. of water and bitumen, leaving 69.55 per cent. of coke, which was very porous and had a brilliant metallic lustre. The same specimen completely incinerated yielded 24.22 per cent. of ash.

No. 2. Lignite; a dull, lustreless specimen, otherwise quite similar to the preceding. Treated in the same way, it yielded 51. 2 per cent. of coke, and 16. 8 per cent. of ash, of a reddish color. No pyrites was observed in it.

No. 3. Lignite; in all respects similar to the preceding. It gave 45. 5 per cent. of coke, and 15 per cent. of ash. This is the best of these coals. The great amount of ash which these specimens contain renders them of little value as fuel where wood can be had, but in the treeless region where they occur they may be very useful if the beds are extensive and occur at a small depth below the surface; as the specimens were probably taken from the outcrop, it is not unlikely that the seams, when further worked, will improve in quality.

No. 4. A lignite from Lake Guzman, in Chihuahua, containing a large proportion of iron pyrites, which, by the action of the atmosphere, has been decomposed and converted into sulphate of iron. It is entirely worthless.

No. 5. Water-worn pebbles of red oxide of iron, mixed with much silica, from Los Nogales, near the intersection of the parallel 31° 20′ north latitude, with the 111th meridian. The specimen which I assayed yielded 32 per cent. of iron; the assay was made by Penny's process, with bichromate of potash.

No. 6. Two small specimens of red hematite, mixed with specular iron ore and quartz, yielding 37 per cent. of iron.

No. 7. Carbonate of lead, associated with earthy black oxide of magnesia and iron ochre. This is a very unusual association of minerals. The magnesia contains no cobalt, as is the case in a similar ore occurring at Mine la Motte, in Missouri. The specimen yielded, in an assay conducted in the wet way, 17. 04 per cent. of lead.

No. 8. Malachite, (carbonate of copper,) enclosing a core of red oxide of copper, containing a few particles of native copper. It yielded 67. 76 per cent. of copper.

No. 9. Red oxide of copper, containing a considerable proportion of native copper, in threads and crystals. The specimen is created superficially with malachite, and is precisely similar to the ore No. 19, from Boca Grande, described in my former report. It will yield about 95 per cent. of copper.

No. 10. A specimen of black oxide of copper, associated with silicate of copper and silica. The mean of two assays gave 50 per cent. of copper.

No. 11. Black oxide of copper, mixed with some sulphuret of copper and quartz, from the Sierra Tule, in Sonora. This is very similar to the last specimen. It yielded 57. 66 per cent. of copper. No silver was found in it.

No. 12. Red oxide of copper, associated with malachite and small particles of native copper, from the Arizona mines, in Sonora. The mean of two assays gave 74. 96 per cent. of copper.

No. 13. A compact silicious ore, containing galena, sulphurets of copper, and arsenical pyrites, intimately mixed with quartz and calcareous spar. It yielded, in an assay conducted in the wet way, 41. 84 per cent. of lead; 0. 12 per cent. silver; and 2. 8 per cent. copper.

No. 14. Galena, associated with variagated sulphuret of copper, carbonate of lead, and quartz. Very slight traces of silver were detected by hydrochloric acid. The specimen yielded 50. 4 per cent. of lead, and 4 per cent. of copper.

I have the honor to remain, very respectfully, yours,

JOHN D. EASTER.

SMITHSONIAN INSTITUTION, *Washington, June* 2, 1856.

SIR: I have the honor to report herewith the results of my analysis of the mineral water brought by the Boundary Commission from Mier, and of a sedimentary deposit said to be taken from a spring in the same vicinity.

The water was contained in two bottles, obtained at different times, one by yourself, the other by Mr. A. Schott. The whole quantity not exceeding one quart, it was impossible to do more than determine the quantity of the more abundant ingredients and the presence of some others. A thorough and minute analysis of a mineral water cannot well be made with less than two to five gallons of water, some of the ingredients being present in exceedingly minute quantities, and yet, doubtless, exerting an important influence on its medicinal properties. The analysis was conducted essentially after Fresenius' method.

This water belongs to the class of neutral salines, the most abundant salt being chloride of sodium. Its specific gravity is 1.003.

A qualitative analysis proved the presence of the following substances: Silica, iron, alumina, lime, magnesia, soda· sulphuric acid, chlorine, phosphoric acid, iodine, and carbonic acid.

It is called a sulphur water, but I could not detect the presence of any trace of sulphuretted hydrogen. It has no reaction on test paper, and its taste is decidedly saline.

The result of the quantitative analysis is as follows:

The whole amount of solid matter is 0.6763 per cent., consisting of—

Silica	0.016586 per cent.
Protoxide iron	0.000754 per cent.
Alumina	traces.
Lime	0.009389 per cent.
Magnesia	0.009580 per cent.
Sodium	0.243323 per cent.
Chlorine	0.340470 per cent.
Sulphuric acid	.010180 per cent.
Phosphor. acid	traces.
Iodine	traces.
	0.630282

Combined in the following manner:

Silica	0.016586
Sulphate of lime	0.017306
Carbonate lime	0.004041
Carb magnesia	0.020120
Carb. protoxide of iron	0.001214
Chloride of sodium	0.628560
	0.687827

The yellow powder (marked No. 25) is a deposit from a chalybeate spring. It was supposed from its color to contain a large quantity of sulphur, but this color is due to hydrated oxide of iron. When ignited, the mass assumed a bright red hue. No sulphur is present in it, but it contains considerable quantities of sulphates and chlorides of lime, magnesia, and soda.

I have the honor to remain, very respectfully, yours,

JOHN D. EASTER.

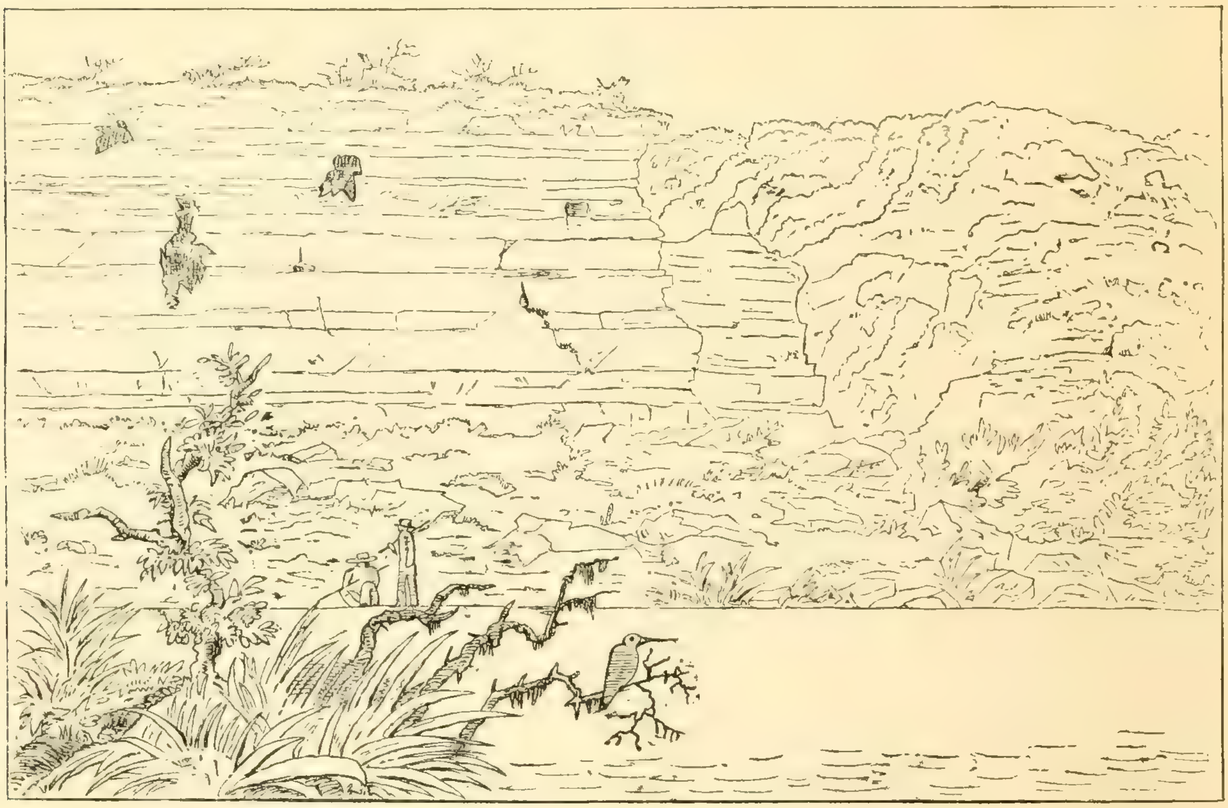
CHAPTER II.

SUBSTANCE OF THE SKETCH OF THE GEOLOGY OF THE LOWER RIO BRAVO DEL NORTE.

[By Arthur Schott, Assistant Surveyor, U. S. B. C., &c.]

Sir: In compliance with your instruction, I have the honor to submit to you the following description of the geological features of the country adjoining the Rio Bravo del Norte, from the mouth of the Rio Puerco (Pecos) to the Gulf of Mexico.

For the whole extent of country thus designated, I shall use the geological term *cretaceous basin of the Rio Bravo,* to correspond to the upper basin, which may be properly characterized as the *carboniferous metamorphic limestone.*



Banks of the Rio Bravo del Norte, 2–3 miles above the mouth of the Rio San Pedro, (Texas.)

Commencing at the point where the Pecos empties its muddy waters into the Rio Bravo, we find for a distance of about 50 miles a high table-land, consisting of solid masses of hard, dark-gray limestone. This formation, viewed in its lithologic character, may be considered as carboniferous; yet the frequent occurrence of fossil remains within its limits hardly admits of its separation from the cretaceous system.

The outside of this limestone is, as already stated, of a dark ash color, often rough, prepresenting the appearance that a violently boiling mud-pool would after being upheaved and suddenly cooled. Its inside is often white or pale yellow, and mealy, with a great tendency to disintegration, which causes a great many holes, fissures, and excavations of every shape and description. These give this limestone a peculiar appearance, and one that is remarked by every traveller.

VALLEYS.

The small, as also the larger, valleys are mostly formed by the continued washing out of the dells and fissures. Thus formed by denudation throughout the whole country, with their borders cracked in every direction, they deserve only the name of deeply cut ravines, (cañons.) This cracked peculiarity may be ascribed to the combined influence of a high temperature, to which this formation may have been at some time exposed, and a subsequent more or less gradual refrigeration. There is scarcely a doubt but that all these table-lands were also formed under the sea, and at the same time exposed to volcanic action. If so, this limestone really deserves the name *metamorphic*, and its somewhat anomalous appearance would be accounted for.

It is our opinion that the limestone of the region above referred to is not of the same character throughout; it is not uniform, and appears under the most variable shapes. It may be seen in various localities, alternating with strata that bear the most striking resemblance to *magnesian limestone.*

STRATIFICATION.

The strata of this formation are generally arranged horizontally; sometimes, however, local disturbances appear which placed them into synclinal or anticlinal positions. The lower strata, often being of less solidity than the upper, and readily disintegrating under atmospheric agencies, are finally washed out into excavations by the action of water. These excavations occur commonly in the beds of ravines, and also in the banks of the river as considerable caves. They are also to be seen near the top of the table-lands and hill-ranges, lying as so many terraces, one above the other; the more solid layers, resisting the action of external agencies, project far beyond the softer.

High table-lands, intersected with deep vertically walled valleys, characterize the face of the whole country. The walls of these valleys, or more properly speaking, cañons, are variously cracked open, and presenting ravines of greater or less extent in all directions.

Those valleys seem to have relation only to the lithologic character of the formation. They are, therefore, usually short, and do not terminate in gradually diminishing fissures, like the heads of rivers and creeks, but suddenly end with a deep chasm under a vertical wall of rock. Deep holes are washed out under these masses of rock, where rain water collects and remains for a considerable time.

WATER HOLES.

Excavations similar to those here mentioned, and retaining water for some time, occur also in the usually dry beds of the tributaries of the Rio Bravo. This is in most cases the only water that can be procured throughout the arid regions bordering the upper portion of the cretaceous basin of the river. Whilst the running water in these dry beds can find its way only by a subterranean passage through the holes and fissures presented by this formation, pools and small ponds of 150 to 200 feet in length and breadth occur in the cavities formed in the solid masses of rock. The valleys of the rivers Bravo, San Pedro or Devil's river, and Pecos, resemble each other in this respect.

BOTTOM-LAND.

Soil suitable for cultivation is scarcely seen in these river bottoms. When small slips of it appear, it is confined to places where a projecting rock or a deposit of mud and drift-wood offers some protection against the violence of the currents everywhere present in these rivers.

Such patches of bottom-land offer the only shelter and home for the growth of trees, consisting almost exclusively of live oak, hackberry, pecan tree, ash, and some two or three species of rhus. The country embraced by this formation is a waterless region, with a barren and rugged surface. There is but one constantly running tributary of the Rio Bravo between the mouths of the Pecos and San Pedro, a distance of 40 miles. The waters of this tributary, of a blue crystal-like transparency, boil out in a deep chasm from beneath a solid mass of limestone, and pour a rapid and full current into the river, but a few paces distant, through dark green shades of flowery and fragrant thickets that line its bed. Its solitary beauty, amid the barrenness and unbroken silence of the surrounding wilderness, suggested a fairy creation, and suggested the name of "Fairy Spring" to this enchanting stream.

Other ravines or "*rock creeks*" afford at times a small stream of clear running water. In their rocky beds occur here and there a series of water holes and small ponds, either isolated or connected only by a trickling run of water. There are several creeks of this character, especially in the vicinity of the Pecos; among which may be mentioned Painted Gallery, Nine-tailed Cat, Oak creek, and Fox-hole.

ANTEDILUVIAL DUNES.

Groups of hills and low ridges, from 80 to 100 feet in absolute height, appear in different localities on the table land of this region. Fossil remains are found on their slopes, and show that they also belong to the cretaceous formation, and constitute its last link. These hills may be considered as accumulations of cretaceous debris, preceding tertiary strata. The irregularity of the line of their direction, and their unmistakeable parallelism with the water-courses, lead to the conclusion that they really once bordered the submarine currents of a vast cretaceous sea, of which the section of country towards the mouth forms a part. Thus we are able to trace these antediluvial *dunes* on both sides of the river, and all its tributaries, not only in its upper part, but even as far down as the point where the cretaceous ridges come into view.

The Rio San Pedro forms a kind of geological boundary, and seems to have some close relation to other physical peculiarities of the adjoining region. Some changes are here perceptible in the fauna, flora, and meteorology; to speak of which, however, is foreign to the matter in hand.

UPPER METAMORPHIC LIMESTONE.

The limestone below the mouth of the San Pedro or Devil's river does not form such solid masses as that above. The high table-lands, already described, change into a more rolling, sometimes broken, country. The rocky portions are only exposed along the valleys and water-courses, whose perpendicular walls, now thrown down, appear only as sloping banks. The lithologic nature of the rock becomes more earthy; its fracture, sharper. It, however, frequently presents a rounded and blunt surface, particularly where there is a tendency to disintegration. The limestone embraced in the section of country lying between the mouths of the rivers San Pedro and Las Moras, like that above, seems to be *metamorphic;* it, however, differs from the limestone above the river San Pedro, in indications of having been subjected to the action of a higher temperature; and its cretaceous character is also proved by the occurrence of fossil remains, which form in some respects a transition from the adjacent geological zone. The surface of this geological belt is completely covered with drift and alluvial soil; and the growth of trees (consisting almost exclusively of mezquite) appears more liberally distributed. Whilst there are scarcely any trees to be seen upon the prominent points, the dells, basins, or flat valleys, where rain-water washes together and deposits the more fertile portion of the soil, are usually invested with scattered groves of the leguminous trees.

HOW WATERED.

The surface of this region is usually dry; it is, however, well watered, when compared to the country adjacent.

The road from San Antonio to El Paso del Norte crosses in this belt (about 40 miles wide) six clear and bold running streams, of which Las Moras, Piedras Pintas, Zoquete, and San Felipe are the most characteristic. They are somewhat similar in general appearance, and in all probability have their origin on a more solid but in a greatly deeper situated stratum; for they pour forth at once their crystal waters either from deep funnel-shaped basins or from rocky clefts. Several of these springs indicate a higher temperature than the water in the streams below.

The water of all these little streams, as also that of the Rio San Pedro or Devil's river, is strongly impregnated with carbonate of lime. Everything hanging within its touch, or in any way exposed to its action, becomes perfectly coated over by its calcareous deposite in a remarkably short time.

In consequence of the permanence and abundance of running water in these tributaries of the Rio Bravo, their bottom-land will in time be highly valued for agricultural purposes. It would be an easy matter to irrigate it, as the fall of water almost throughout is very considerable.

INTERSPERSED STRATA.

The groups of hills mentioned before as placed upon the table-lands of the country between Devil's river and the Pecos, appear again in this belt as belonging not only to the later strata of the cretaceous system, but also apparently to a still later date. These strata are usually met with, bordering and constituting the edges of the different valleys. The fossils occurring in these localities are also of the age just mentioned. As an essential characteristic, we cite here strata and shoals consisting almost solely of entire and fragmentary pieces of *Exogyra*, *Arietina*, (Roemer.) They appear either in a state of perfect preservation, or as a real breccia; the cement of which is mostly an ochre-colored calcareous sand or clay.

The stratification of this formation shows a succession of layers of variously tinted marls, of more or less coarsely grained sand, and also of differently colored limestone; all are profusely impregnated and sprinkled over with oxide of magnetic iron. Some of these strata contain pieces of the latter formed into every shape, but most commonly give to the matrix the real habitus of volitic texture.

This imbedded formation increases as you approach its lower edge, (Las Moras,) leading to another change in the lithological features of the country along the Rio Bravo.

Before considering this change, however, another fact of much geological importance is not to be overlooked.

THE DYKE.

About twenty miles below Las Moras is Elm creek, (Arroyo de Los Olmos,) the next tributary of the Rio Bravo on the Texan side. Its valley belongs to still another geological belt; none of the more solid metamorphic limestones before referred to are now to be seen. The whole country from Las Moras to the mouth of the Rio San Juan, and even as far down as the vicinity of the Mexican town of Reynosa, forms another link of the cretaceous system; a more soft and brittle sandstone, (partly chloritic?) varying in grain, color, and cohesion, constitutes the main part of this formation. This resembles very much, if it is not in reality, the green sandstone or chloritic chalk itself.

Its northern limit, where it joins the more recent metamorphic limestone some distance below the Las Moras, is distinctly marked by a line which shows on the surface or in the soil signs of a geological disturbance. This limit is the valley of Elm creek, two miles and a half above Eagle Pass. It is wide and flat; the ridges of hills bordering it are often overthrown and washed down, whilst the horizontal strata in many places are brought into synclinal or anticlinal positions. The creek itself, not the one of that name on the El Paso road, is sluggish, and carries only a dirty, greenish, and brackish water, which often disappears in its bed, leaving only here and there small ponds and muddy pools. Out-crop of pretty extensive beds of lignite coal occur on both sides of the mouth of this creek well worthy of examination, and may prove to be of commercial value.

These coal-layers probably gave the name "Piedras Negras" to the Mexican military colony in the vicinity. The aspect of the valley of Elm creek, and the character of the country to the right and left of the Rio Bravo at this point, justify the idea that a subterraneous volcanic dike crosses the basin of the Rio Bravo. By turning for a moment from our course along the Rio Bravo, and proceeding from the mouth of Elm creek in a direction southwest by south for about seventy miles, we reach the foot of a high and bold mountain range formed of metalliferous limestone, (*zechstein*,) the precious contents of which once made Santa Rosa famous as a silver-mining town.

On the line between the Rio Bravo and the Santa Rosa mountains, the face of the country shows many signs of a geological disturbance; the usually undulating region becomes more broken, whilst the flat, long-stretching ranges of hills are frequently overthrown. The slope of the Santa Rosa mountain is rocky, wildly broken, and steep, and large portions of the strata are entirely dislodged and most anomalously placed. The stratification here is not only seldom horizontal, but frequently thrown up vertically. There is some regularity, however, in this apparent disorder, particularly with respect to the parallelism—the characteristic of all the cordilleras of the American continent.

PARALLELISM AND VOLCANIC CROSS AXES OF THE MEXICAN CORDILLERAS.

By this parallelism is meant an inclination of the chief sierras to separate into collateral sub-sierras and side branches, which again join the main chain; or they are at least connected either by cross sierras, or even simple dykes. To this striking peculiarity the profiles of both the northern and southern portions of the western hemisphere are due. This mountain range of Santa Rosa presents another characteristic, and one, according to Alexander von Humboldt, peculiar to the mountain system of Mexico—it is, that the volcanic axes cross the direction of the Cordilleras almost always at right angles. There are many cross-valleys on the northeastern slope, proving the action of some volcanic disturbance; a valley some eight or nine miles east of Santa Rosa, called "El Potrero," is the most remarkable instance. Several mines are still worked here, where the metalliferous limestone is variously traversed by veins of feldspar and limestone spar; this latter usually accompanies the silver ore and galena. In the centre of this *cul de sac*, a better name for this so-called valley, can be seen an ancient crater, the inner walls of which are thickly coated over with a lava-like basalt of a dark red hue, whose composition differs apparently but little from that which covers in layers (20 or 30 feet thick) the cretaceous range of hills joining the northeastern slope of the metalliferous mountains.

It may, perhaps, be of importance to state that the argentiferous portion of the Sierra de Santa Rosa is not more than ten or eleven miles in length, commencing at a point called "El Cederal," (the Cedars, Cedar Grove,) and terminating at a place, in a northwest direction, bearing the name of "Los Nogales," (the Walnuts, Walnut Grove.) The presence of ores, together with the trap or basaltic dykes branching out from the sierra at right angles, may prove the supposition which places here the origin of the volcanic power, that, pushing through the fissures of stratified rocks, causes the dyke before alluded to. Following this dyke from Santa Rosa up towards the Rio Bravo, it will be found to cross the valley of this river in the vicinity of Elm creek, as already stated.

BASALTIC HILLS—VOLCANIC DYKES IN TEXAS.

On the Texan side, the first marks of volcanic action are to be seen at the head of Leona river. Here a solitary hill of 60 to 70 feet in height occurs, formed entirely of a dark green basalt which is closely allied to that of the Santa Rosa mountains, and which also contains much *hornblende* and *olivine*. In the vicinity of Fort Inge, and also near the head of Las Moras, are several hills of the same nature; also the road from Leona to the first crossing of Devil's river leads over several places indicating volcanic action.

The west bank of the Rio Frio, at the crossing, is formed of a solid mass of basaltic rock; which undoubtedly belongs to the dyke alluded to as having its origin in the Santa Rosa mountain, and here crossing the cretaceous formation.

DR. ROEMER'S VIEWS.

Dr. Roemer, in his not yet translated work, entitled "Die Kreidebildungvon Texas," ("The Cretaceous Formation of Texas,") mentions (page 8) that plutonic or volcanic rocks were brought to him from between the San Saba and Cibolo; and according to him, granite, together with older stratified rock, is seen in narrow strips, surrounded with cretaceous strata, between the

San Saba and Pedernales. Again, about fifteen miles due north of Fredericksburg isolated granitic rocks have been met with, among which is the "Enchanted rock," of popular renown.

Also, between the Llano and San Saba granite protrudes through cretaceous strata; and sixteen miles north of Fredericksburg occurs a coarse-grained granite, consisting of flesh-colored feldspar, gray quartz, and some little black mica.

In other places along the Llano very finely grained varieties of granite have been observed. Granite, frequently interspersed with veins and fragments of a white quartz, also appears at various points. Pieces of syenite, too, have been found along several of the tributaries of the Llano.

Besides these plutonic forms, trap-like rocks also seem to occur in many places of the country referred to by Dr. Roemer. Again, this author received from twenty miles to the northeast of San Antonio de Bexar pieces of a black basaltic rock, which protrudes in veins through the cretaceous limestone strata. In this basalt, as component parts, are many minute crystals of a white fossil, (glassy feldspar?) and also a dark, olivinish fossil.

The geographical distribution of the rocks of which Dr. Roemer speaks permits only the conclusion that all the marks of plutonic or volcanic formation must belong to the same system, which, traversing the upper limit of the more recent cretaceous strata in the valley of the Rio Bravo, shows itself in the shape of the low basaltic hills mentioned as occurring at the crossing of the Rio Frio, and at the heads of the rivers Leona and Las Moras.

There is no doubt that this dyke continues its northeastern direction, accompanying as an outlayer of the higher regions of the Guadalupe and Ozark mountains, and thus probably crosses the whole of Texas, and possibly Arkansas.

METEORIC IRON.

With regard to meteoric iron, to which Dr. Roemer refers in connexion with the plutonic rocks, and of which he mentions a large specimen now preserved in Yale College, we have to state that, besides magnetic iron ore, which is scattered in loose innumerable pieces of every shape and size over the whole surface of the cretaceous basin of the Rio Bravo, meteoric iron is known to exist about ninety miles northwest of Santa Rosa. An American resident of this town, Dr. John Long, called my attention to a piece weighing some twenty-five pounds, which was then in the possession of a Mexican; small pieces had been cut from it, and hammered out without the aid of fire into some trifling articles. It is said that the whole surface of the area (embracing about thirty acres of land) where the deposition of this valuable mineral occurs is covered with blocks of it, of greater or less extent, some containing as much, and even more, than thirty-six cubic feet.

GREEN SAND WITH LIGNITE.

The upper limits of that portion of the cretaceous basin, which consists chiefly of strata of green sand, and the course of the volcanic dyke discussed above, seem rather to run parallel than approach each other.

So far as our observations extended, the main portion of the cretaceous basin, from Las Moras to the vicinity of Reynosa, forms a belt of 380 to 400 miles in width.

The upper part of this belt commences in the vicinity of Las Moras, and terminates some few miles above Laredo, a distance of about 200 miles, whilst the lower part begins where the former ends, and reaches as far as the vicinity of Reynosa, showing a width of about 340 miles. Both of these parts are distinctly characterized by strata of green sand, (chloritic chalk,) which change, according to the amount of oxyde of iron they contain, into variously tinted sandstone shoals. The solidity of the strata varies very much. They are sometimes formed into very solid rocks, well suited for mechanical or architectural operations; again, they consist of loose and coarsely-grained sandstone slate, which rapidly crumbles on exposure to the air. All these green sand strata are frequently intersected with layers of debris of analogous character.

In several places where these green sand strata were disintegrating, and being carried off by the action of the waters, there was observed a white, salty efflorescence, which may possibly be "ammonia." The "Rocky walls" near the mouth of the Arroyo Castaño, which is about 40 miles below Eagle Pass, and near the Presidio de San Juan el Bautista, are remarkable for this efflorescence, as also some terraces below this point. The frequent occurrence of a certain chenopodium, containing a large amount of this salt, and often covering exclusively wide tracts of sandy bottom-land along the Rio Bravo, may prove more conclusively the peculiar elements of the green sandstone.

The green sand, particularly in the upper belt, is often and variously intersected by strata of different nature, though certainly closely allied with the same system.

Strata of sandy or argillaceous marls, or blue or grayish clay, all profusely impregnated with oxide of iron, and even layers of corresponding debris, often intersect the green sand strata.

The general characteristic of this belt and its subdivisions is the strict horizontality of its strata throughout. It is only here and there that some slight local disturbance has taken place, as, for instance, near Laredo, and again some 40 or 50 miles above, where a dip of about 8° W.S.E. and E. is exposed.

The following peculiarities may serve to characterize the two subdivisions of the green sand belt:

LIGNITE COAL.

From Las Moras to the vicinity of Arroyo Sombreretillo, which is about 10 miles above Laredo, lignite coal occurs quite frequently. None came under our observation below this point; outcrops of it, however, are said to be found in the neighborhood of Roma, some 10 miles above the mouth of the Rio San Juan.

Though there is not much doubt of the existence of lignite below the Arroyo Sombreretillo, our observations have led us to the conclusion that it is more sparsely distributed.

These lignites vary both in appearance and quality; sometimes they are found to be scaly or slaty, and of a dull earthy fracture, sometimes resinous and sharply edged. Prints, and even remains, of plants, preserved in these coals, indicate vegetable forms of the higher orders, as gramineæ, (perhaps reed and cane,) and even parts of dicotyledonous trees, such as willow or ash. Other specimens of coal from below appear more amorphous; but it contains so much bitumen as to be of no use in the blacksmith's forge, where it runs together and becomes baked into a solid mass.

The localities remarkable for the most considerable deposits of lignite coal are the following:

On both sides of the mouth of Elm creek, near Eagle Pass, particularly on the north bank of this water-course, where layers from 3 to 4 feet thick are exposed. On the south bank of this creek, also, and quite near Eagle Pass, several conspicuous layers are seen. A blacksmith, once connected with the garrison at Fort Duncan, used this coal for some time in his shop; and having satisfactorily tested its value as an article of trade, went to mining it. There was a ready market at San Antonio; the cost of the labor, however, in getting it out, together with the great expense of transportation on account of the Indians, put an end to the mining operations of this enterprising individual.

Small seams of coal appear also on the Mexican side of the river, just below the mouth of the Escondido, which is two and a half miles below Eagle Pass.

The thickest layers of coal noticed, however, are on the slope of the Lizard hills, below the deserted rancho Palafox; a more bituminous coal occurs here in layers from 4 to 5 feet thick.

According to our experience, the finest and best of all the lignite coal in the valley of the Rio Bravo is that which occurs in the neighborhood of Arroyo Sombreretillo. This is apparently the most bituminous observed on the whole line.

Off from the river, near Santa Rosa, lignite coal was seen. Although its layers are thinner, and its quality inferior to the various deposits heretofore alluded to, yet its relation to and close connexion with them hardly admits of a doubt. The layers, generally horizontal, are here thrown up almost vertically; which position is the natural consequence of their being placed near the basaltic dyke frequently referred to before.

BITUMEN.

It is but proper to mention here the occurrence of another fossil, not less interesting and valuable than coal. This is a sort of fossil resin or bitumen, which was met with in loose scattered strings on the slope of "White Bluffs," about 20 miles below Eagle Pass. Some few and but small specimens (such as could be saved) were sent to Dr. John Torrey for examination, who found them to be similar to a substance which he had received some time previous from the province of New Brunswick, and examined in order to elucidate a law-suit there pending. Can it be that the occurrence of this fossil in these extreme cretaceous localities proves a close relationship between their respective strata?

BLUE OOLITE-LIKE LIMESTONE.

Other intermittent strata of the upper green sand belt may also be considered as characteristics. For instance, there appears frequently a blue coarsely-grained limestone of a decided oolitic texture, often showing a somewhat crystalline and sharp fracture. This is sometimes alternately intersected by and covered with an ochre-colored stratum, usually of a more sandy structure. Both of these rocks abound in fossil shells of a more recent cretaceous, if not of tertiary age. They cannot, for this reason, be pronounced as truly oolitic, however much their structure and appearance might justify such a supposition. Wherever this limestone occurs, it affords to the inhabitants the material for building their houses, and is also burnt in kilns for domestic use. May it possibly be identical with the "Calcaire grossoir" of the French? Some strata of this limestone show large masses of a compound, consisting either of magnetic iron combined with sand and marl, or clay, or an aggregation of the latter strongly impregnated with the former.

BLUE CLAY.

Besides this limestone, there are strata of a dark gray, sometimes blue, clay, which either cover or intersect the layers of green sand. This clay is often hard and rock-like, forming sometimes extensive reefs and banks, which seriously obstruct the navigation of the Rio Bravo. In other places, especially where it is under water, it is soft, and can be moulded between the fingers like plastic clay, to which it is closely allied, if not identical with it. The renowned rapids of the "Isletas," in the vicinity of the Mexican Presidio San Juan El Bautista, are formed by this clay. Above this place, some 10 miles, are similar clay deposits covered with shoals of oyster-breccia 2 feet thick, pieces of which were added to our collection of fossil specimens.

A clay similar to this usually accompanies the lignite coal that has been referred to above.

These are, then, the characteristics in which the upper portion of the green sand belt differs from the lower, where alternating strata of sandier compounds prevail, instead of the argillaceous, as in the former.

THE GREEN SAND WITH FOSSIL OYSTERS AND SHELLS.

As the frequent occurrence of lignite coal characterizes the upper belt of green sand, so the banks and shoals of fossil oysters indicate the lower.

These oysters, together with conglomerated shoals of shells, seem to be of an age still later than the fossils of the cretaceous period above ; some, indeed, would seem to belong properly to the tertiary strata.

The lower portion of this green sand belt appears generally as if it were constituted a part of the eocene system.

The prints and remains of dicotyledonous and monocotyledonous leaves and plants in the lignite coal, with some fossil shells of later age, led to the conclusion that all such fossiliferous strata belong to the tertiary period, which, however, seem to have only a local distribution throughout.

In this belt tertiary deposits occur very generally, sometimes constituting extensive tracts of land.

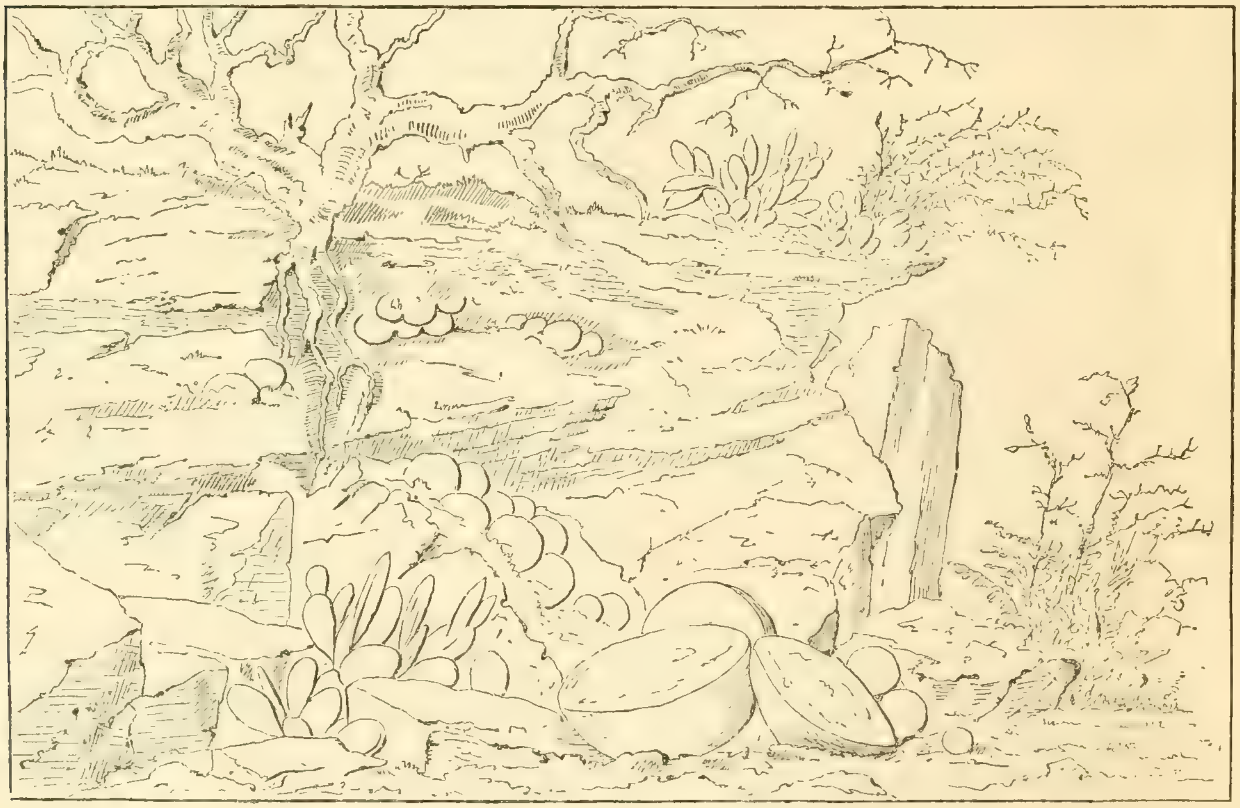
The fossil oysters and shells before spoken of are of the largest size ; and extensive banks of them are seen at several places along that part of the river embraced by the lower green sandstone belt. Of these, we may instance Roma, the Island Las Ajuntas, Shady Bluffs, near Mier, and a point some 25 to 30 miles above the mouth of the San Juan. Other similar fossils are often found at these places covered with a perfectly chalky-white coat.

Slate-like sandstone often intersects the green sand, and forms at a number of points massive walls of considerable extent ; the adhesive quality of the particles of this rock, however, is often not very persistent. Its inside is very soft and readily crumbles, as is shown sometimes by the disintegration of the outer coat.

SEPTARIAE.

Another peculiarity of this lower belt is the frequent occurrence of a variety of septariae. The highest place in the valley where they were seen (probably only as drift) was between Elm creek and Las Moras. Further down the valley, however, they are more abundant, and just below the mouth of Arroyo Sombreretillo they make their appearance quite frequently. Again below this point they are still more plentiful. On the oyster-terraces, some forty miles below Laredo and near the Rancho San Ignacio, there is a spot remarkable for the abundance of this fossil; as are also the following places: the slope of "Red Ridge," of "Shady Bluffs," and Septariae Hills. Their most common shape resembles very much a small, flat loaf of bread. Both on the out and inside large irregularly-shaped divisions, like cob-webs, are to be seen, which seem to have been formed by a net-work of veins composed perhaps of crystals of gypsum, which commonly abounds here. This fossil is in all probability to be referred to ludus helmontii, (turtle stones.)

The largest septariae of this kind was seen at Laredo, whither it was brought from the vicinity of the Arroyo Sombreretillo. The whole piece, 2 feet across and nearly 1 foot thick, consisted only of the cob-webbed part, showing cellular aggregations of a silicious matter; its color was pale yellow.



"The Bombshell Bluff," on the lower Rio Bravo del Norte, Texas.

Fragments of similar septariae, if these latter deserve that name, were also found in several other localities below Laredo. Other aggregations, septariae-like in character, are seen as balls or nodules of various sizes, composed of a pale green sand imbedded in a similar but more brittle marly matrix. Clusters of such balls abound under some green sand bluffs near Rancho Clareño; from the size of a three-pound cannon shot up to that of the largest bombshell—sometimes entire, sometimes cracked in two. So striking and peculiar are these rocks, as to be justly entitled to the name of "Bombshell Bluff," with which they were christened.

FOSSIL BONE.

The lower portion of the green sand belt reaches as far down as the vicinity of Reynosa, which is about 200 miles from the Gulf. Here the last cretaceous ridge of hills approaches the valley of the Rio Bravo, though no rocks are exposed on its banks.

Tertiary strata seem, however, to occur alternately throughout the whole country. Many bluffs and ridges may be referred to this formation; for a fossil bone was taken out of a bluff near Camargo, on the Rio San Juan, and was in the possession of a resident of Eagle Pass, who stated that many such interesting remains of fossil fauna were to be found in the same and similar localities.

FOSSIL WOOD.

As to the presence of tertiary strata in the valley of the Rio Bravo, it would be proper to add here another suggestion based upon the frequent occurrence of fossil wood; by a close examination of which. some three or four genera or species might be classified.

The mouth of Elm creek is particularly distinguished for the abundance of fossil wood, which is usually found here scattered about as if brought down from some higher localities; yet pieces of trunk and branch sometimes were so arranged as to lead one to suppose that they once belonged to a tree on the spot, which had just fallen to the ground. Not far from this place, and very near the layers of lignite coal before spoken of as lying adjacent to Eagle Pass, the trunk of a fossil tree was discovered in one of the innumerable ravines cutting the borders of the Rio Bravo valley, 2½ feet in length by 15 inches in diameter. The largest pieces of fossil wood, however, were noticed in the environs of Santa Rosa; it abounds especially at the foot of the table-land ridges, running out in a northerly direction from the main ridge of the argentiferous mountains. These flat ridges, called by the inhabitants "Las Mesas" or "Lomas," belong to the cretaceous system, and are covered with strata, from 20 to 30 feet thick, of basaltic rock and trap or basaltic tuff.

So far as could be seen with the naked eye, there is not much difference between the texture of this fossil wood and of that near Eagle Pass and at other places along the valley of the Rio Bravo. Most of this fossil wood possesses apparently the structure of the palm-wood. The color of the specimens from Santa Rosa, however, is quite different from the rest. They show a dark reddish brown, much like the basalt in their neighborhood, placed on the top of the mesas. It seems highly probable that this wood may have been at some time in contact with these igneous and eruptive rocks, and that this red brown color was imparted to it by a certain proportion of oxide of iron.

The larger pieces of this fossil wood have been carried to town to serve as corner-stones. Some of these measured from 3 to 3½ feet in length by from 12 to 18 inches in diameter. The large size of the Santa Rosa specimens, compared with those found in the valley of the Rio Bravo and the surrounding country, led us to conclude that the former were not brought from so great a distance as the latter; in fact the former could not have originated far off, because the tertiary strata, which are undoubtedly their home, cannot be sought for on the top of the Santa Rosa mountains, bordering as these do the cretaceous basin of the Rio Bravo.

Whether all the fossil woods of the various localities mentioned are endogenous or not, we are not prepared to state; though we think it is possible that some of it may be correctly referred to the coniferae.

This fossil wood belongs to both of the subdivisions of the green sand belt, and may be ascribed to them as a geological characteristic; it occurs more frequently, however, in the upper portion. It is not only to be found in low places, in the bottom, and on the borders of valleys, but also in the midst of the elevated and vast prairies that stretch from one water-course to another. It here lies scattered broadcast among the pebbles of the diluvial drift that covers all the plains and slopes.

PHYSICAL FEATURES OF THE COUNTRY.

The section of country embraced by the green sand belt, though somewhat similar in its outlines to the table-lands of the cretaceous limestone above, presents a more gently undulating surface. Although the upper side of this belt shows the horizontal stratification of the cretaceous system, yet, being interspersed with ranges of hills and ridges of a later age, (and even of tertiary origin,) the land as a consequence becomes more rolling. The substrata of limestone which constitute the beds of the clear water streams between Las Moras and San Felipe being placed much deeper in the lower country, and probably out of contact with the subterranean strata of metamorphic rocks belonging to the volcanic dyke of the country, may account for the general dryness of the green sand region; for this seems to be entirely deprived of running streams, as elsewhere stated.

The dry water-courses, sometimes cut from 50 to 80 feet deep, show only at distant intervals pools or ponds. These reservoirs contain a dirty, green, brackish water, on which man with the wild and domestic animals alike have to depend. This water benefits but little the surrounding soil, which affords at most only a scant vegetation. Narrow and limited strips only, bordering on the immediate edges of these ponds, flourish with the vegetation of a well watered soil. These water-holes, though, bad as they are, are real oases in this desert region, and afford the only meeting places of animal life; here, the white man, a traveller, and for the most part peaceable in his pursuits, the Indian, more or less hostile to civilization and humanity, and the herd-driving, half-breed Mexican, seek this indispensable gift of nature.

Such places are easily recognized, even at a considerable distance, by the presence of numerous and various flocks of birds, and a nearer approach shows them to be marked with a denser growth of trees, shrubs, and weeds. They constitute a distinct characteristic of these regions.

Between the densely covered borders of these watering places and the bare slopes and arid heights, dells, basins, and all other varied depressions, almost always exhibit a more luxuriant state of vegetable life. This condition may be explained in part by the increased hygrometric capacity of the atmosphere, however little moisture may be deposited. Here, also, the rain-water sweeps together the more fertile particles of the soil, which, possessing a great deal of moisture, comparatively, causes vegetation to spring forth. In this same belt of country, on the Mexican side of the river, there are more running streams than on the Texan side; and for the reason that the conditions on which their origin and existence depend, are less distant, as will be made evident from what follows.

Sierras or mountain ranges, formed of igneous and metamorphic stratified and unstratified rocks border, on the Mexican side, the cretaceous basin of the Rio Bravo. To these that side of the river is indebted for running water in the shape of several large, clear-water streams. Where there is hardly one running stream on the Texan side, on the Mexican are six, which carry no inconsiderable quantity of water in the Rio Bravo.

Besides the small streams, very changeable in their supply of water, the following are remarkable for their constant flow:

Escondido, near the head of which is situated the town of San Fernando, has its mouth about three miles below Eagle Pass.

Las Cavezeras, heading in the immediate vicinity of the Escondido, with the little town of San Juan de Allende and Nava near its source, empties some thirty miles above the destroyed rancho Palafox.

The Salado, carrying what may be considered here a large body of water, which is supplied by several large branches from near Santa Rosa, (Sabine, Alamo, and others,) commingles its waters with the Rio Bravo some eight miles below Guerrero, and nearly opposite Redmond's rancho.

Alamo, having its source in, and bringing its waters down from, a more southern portion of the Mexican Sierra, falls into the Rio Bravo near Mier.

The San Juan, gathering its waters in still more southern portions of the Sierras which form the highlands of the States of Coahuila and Nueva Leon, empties just below Camargo.

There is almost no running water on the Texan side from the beginning of the green sand belt down to the mouth of the Rio Bravo, if we except some few sluggish, half-underground, trickling creeks. If it were not, however, for their subterranean course, which prevents entire evaporation, this region would be wholly destitute of water.

The state of water near the mouth of these creeks is always affected by the rise or fall of the river, and also by the hygrometric precipitation of the atmosphere, however small quantities this latter may contribute.

These peculiar water-courses form a characteristic feature of the country through which they run; and their thorough knowledge gives advantages to the natives, by which they elude the pursuit of the white man, and render his efforts of no avail.

THE ISLANDS.

Another peculiarity of the portion of the Rio Bravo that winds through these cretaceous regions is the frequent occurrence of islands, various in size and appearance.

Whilst in the upper part of this cretaceous main the size of the islands is reduced to that of mere bars and reefs, (bare, or covered with rush and cane,) further below their absolute height above the water increases, and consequently the number of vegetable forms growing upon them.

As nearly all the islands are formed by alluvial deposits on stratified rocks, the layers of which they are composed assume or are arranged in a strictly horizontal position. As a matter of course, therefore, the down-river end usually rises high above the water, while the up-river end always appears partially covered with muddy and gravelly deposits and driftwood and the like that the river is continually carrying down.

Above, the islands are only mere banks or mud-bars, brought in by the tributaries and deposited according to the action of the currents of the river. Where the current is rapid and the course of the tributary is short, as is the case between the Las Moras and San Pedro, islands are not formed in the middle of the river; here they occur only as long narrow stripes of half immersed bars and banks below or above the mouth of the tributary that causes them. Sometimes the force of the river keeps back the deposit, and causes the formation of the island within the mouth of the tributary; such a case is presented at the mouth of the Arroyo "Piedras Pintas."

Where the water is sluggish in the river and a strong current in the tributary, the islands are pushed further out from the mouth of the latter.

Islands, rising to the height of the alluvial banks of the river, 20 to 30 feet above the water, do not occur above Eagle Pass.

Cazneau's Island, named in honor of an American gentleman who resided in this vicinity for several years and cultivated it to some extent, is the first that is situated above the common high-water marks. Such, however, are rare between Eagle Pass and Laredo, and it is not until reaching a point some ten miles above the latter place that another island occurs which would be worthy of consideration for agricultural purposes.

Below Laredo, the first island of this kind is "Isla de los Rancheros." With this commences a series of about twelve, which the Mexicans cultivate, raising corn, tobacco, melons, pumpkins, and other produce for domestic use.

To facilitate the identification of these islands, the following names were given to them in the topography of the survey: Mustang Island, Belvidere, Maj. Brown Island, Carriso, Melon, Green Tassel, Patriarch, Cypress, Island of Last Rocks, Isla Los Ajuntas, Beaver, Sabine, and Green Key; the latter one being only a narrow flat strip, subject to inundations, ought rather to be classified with the islands of the upper region.

Among the islands here mentioned, Los Ajuntas, near Mier, is, in consequence of its size and fertility, the most valuable. It is also the largest one of all, being 2½ miles in length by almost ¾ of a mile wide; its upper part is heavily timbered, whilst its lower is open, and constantly under cultivation.

At the mouth of the Salado, and thence downward, the shore and banks of the Rio Bravo are of a softer character; the former is more muddy and sometimes miry, while the latter, disintegrating and washing down, lay the foundation for, and causes an increased growth of, vegetation. The soft soil, with the luxuriant undergrowth, added much to the labors of our surveying party.

At the Island of the Last Rocks, shoals and reefs, obstructing the navigation, make their appearance for the last time in the bed of the river, though rocks are still seen on both sides along the shore. If rocks do appear in the bed of the river further down, no danger is to be apprehended from them because of their depth below the surface.

The lower part of the green sand belt undergoes still another change in its external appearance; this is quite perceptible at the mouth of the Rio Salado, and downwards continuously from that point. The frequent occurrence of oyster banks and shoals, together with the external appearance of the strata, seem to verify the inference that the regions here and below are of a still later age than the green sandstone belt.

The Rio Alamo seems also to indicate a distinct line in the geological features of the country.

Besides the presence of extensive fossil oyster-banks in its vicinity, there is below its mouth, on the Mexican side, a most rugged and naked spot, which presents the appearance of having just been torn to pieces by some destructive freak of nature. The scene of this apparent catastrophe now constitutes a wide flat basin, which is arid and literally cut up in every direction by ravines and rills. On the borders of these ravines, which run to a common centre and form a pool of water known as the "Sulphur Spring," are to be found a sulphur-colored earth, probably alumn and sulphur. The mineral water of this spring just now under examination tastes strongly of sulphurated hydrogen gas, and after standing for some hours in a vessel, collects a black deposit on the bottom. This water is celebrated in the country around for its medicinal properties. When the American army was camped near here during the Mexican war, it was much used on the recommendation of the surgeons.

Here, within a distance of about 2½ miles, several water-courses empty into the Rio Bravo, and form by their deposits a large island, which, as a result of this united action, was named "Los Ajuntas;" besides the Alamo, already mentioned, these tributaries are the Sulphur Spring, the Saladito, and Arroyo Hondo.

THE FLORA.

The flora of both the green sand belts show, as to the number of genera and species, various additions, and a more luxuriant development when compared with the vegetable life of the regions above.

As instances, the Huisache and Guaxillo, and other plants, all of the Mimosa family, growing above only as arborescents, gradually rise in these belts, and further down in the valley, to the size of conspicuous trees, often forming dense copses in the old beds and on the banks of the river. Of the several genera added, especially noticeable, are the Coma tree, the Nacavites, the Anacua, and Sabina; the latter two seem to have been brought in by the Rio Salado.

The appearance of the Cypress (Taxodium) Sabina of the Mexicans makes quite a striking change in the physiognomy of the country. This water and rock-loving tree often appears right in the middle of the swiftest currents of the river, where having taken hold of some rocks on the bottom, it boldly defies the force and action of the water. These cypresses on the Rio Bravo, commencing at the mouth of the Salado, extend as far down as Beaver Islands, just below Roma, where they make their last appearance in the channel on the Mexican side, footing in water from 14 to 15 feet in depth.

THE COLLUVIAL BELT.

After passing the lower green sand belt, (geographically speaking,) which has its lowest limits in the vicinity of Reynosa, as already stated, the colluvial commences and extends down to the coast. Under the term "colluvial" we include both the diluvial and alluvial deposits; these are irregularly and somewhat alternately arranged—the result of the oscillatory action of the salt waters from the sea-side, and the antagonistic and downward force of the fresh waters.

It is on account of this irregular distribution that the colluvial belt cannot be properly subdivided into a diluvial and an alluvial portion. Topography and, in some degree, botany, may, however, aid in examining, in its subdivisions, this lowest belt of the cretaceous basin of the Rio Bravo.

From Reynosa to the Rancho Lomita, 18 miles above the mouth of the river, the surface of the country is of a gently undulating character, which is accounted for in the fact that the colluvial deposits rest upon underlying cretaceous strata, which become deeper and deeper as the coast is approached. The river is now more serpentine in its course, and at almost every one of its numerous bends may be seen a lagoon, pond, or pool, in which thousands of water-fowl collect and feed. There is little or no tendency in the river to form islands towards its mouth, where it becomes narrower; its bed, however, is always undergoing constant and rapid changes. No bend, under the capricious action of eddies and whirlpools, retains its form for more than a season.

We noticed at several points, where a new bed had been formed a short time before, that there was scarcely any perceptible difference in the strength of the two channels, the river taking its course through both with equal force and volume. The boatmen not unfrequently found themselves in a sort of "steering dilemma" at such places, not knowing which was the channel. The outlet of the old bed, or its junction with the new, presented quite another aspect, and certainly not inviting entrance to those who come *up*.

It is in this region that the vegetation of the Rio Bravo displays its highest and most luxuriant development.

All the bottom-land, not under cultivation and not subject to the action of the water, is covered with dense thickets, almost wholly impenetrable, composed, as they are, of lofty trees as well as of smaller undergrowth, and of a great variety of creepers and vines, springing up from every spot not otherwise occupied, and filling up all the open and shady spaces, from the foot to the topmost branch of every tree and bush. It is also in the lower portion of this belt (where the Palm tribe is represented by the Chamaerops Palmetto) that the Palmetto attains a growth as gorgeous even as that on the Lower Mississippi; it extends on the Rio Bravo up to about 80 miles from the Gulf. In addition to the Palmetto common to the lower portions of these two great rivers, the constant appearance of a Tillandsia (Spanish moss) depending from the branches of the trees in long clusters increases the similarity of their scenery. Whilst the existence of this moss proves a higher degree of atmospheric moisture here than in the country above, the occurrence of the Palmetto may indicate the vicinity of the sea.

There would, perhaps, be no mistake in placing the limits of the maritime belt where the growth of the Palmetto ceases, particularly if we take into consideration the fact that several salt-water loving plants keep company with this representative of the Palms. The real coast belt, however, in the true sense of the word, may be placed with more propriety in the vicinity of the Rancho Lomita, 18 miles above the mouth of the river.

THE COAST.

Lomita, the diminutive of Loma, a long, somewhat flat hill or ridge, forms one of the last topographical monuments on the Rio Bravo. These consist of a low ridge of calcareous clay, bare and almost entirely deprived of any vegetation whatever. The ridge on which the town of Lomita is situated, like several others below, shows marks of being continually under the destructive action of the tide of the sea and flood of the river which meet here.

From Lomita down the land shows the real character of the seacoast, the vegetation decreasing gradually towards the mouth of the river. Most of the trees here yield the field almost solely to some few members of the Mimosa family, of which latter the Huisache maintains its place nearly down to the tidal sand-banks of the gulf.

Lagoons, old river beds, ponds, swamps, pools, bayous, and other similar phenomena now constitute the lowest belt. Here the deceptive mirage constantly bounds the distant horizon, and the scenery, under its influence, presents to the mind but a chaotic dream still hovering over the land—a twilight gift of creation.

Besides the regularly occurring ebb and flow of the tide, which was observed at Rancho Lomita varying from about four to six inches, the fauna of the water indicate that the maritime belt has its upper limits in this vicinity. Some little distance below Lomita a two-valved shell and a decapoda, the camaron of the Mexicans, announce the proximity of the sea. Both of these animal forms seem to go up as high through the alluvial deposit as the tide affects the river.

ALLUVIAL DEVELOPMENT.

There is another portion of this lowest and most recent formation which, still under the continual action of both salt and fresh water, might be considered only as a rudimentary development of the alluvial belt along the coast. Not having yet risen above the level of the water, it is called, in the language of the sailors and pilots, the "bar." Such a place affords a home only for the various marine crustaceæ, and the meeting ground of the sea-fowls, the wreckers of the population of the air.

In regard to the topographical features of the coast, it may be completely characterized by the statement that it consists partly of the fragments of the solid parts of marine animals, partly of entire or decomposed vegetable forms, partly of deposits of inorganic matter, and partly also of fragments of animals, vegetable matter, and other material brought down by the river. Washed off and brought back again by the varied motions of the waves—sometimes united, sometimes antagonistic—as a matter of course this adjunct of the colluvial belt is always undergoing a change. This is, however, strictly regulated by the varying amount of power exercised on the one hand by the irresistible waves, and on the other hand at times by the no less forcible flood of fresh water. Agents of the sea are atmospheric currents and ebb and flow of tide; antagonistic to these oscillatory movements are the forces of the river, influenced by the hygrometric conditions of the air and the hyetographic state of the seasons in the country above and along the river.

The bar, though a mere toy under the action of the forces just mentioned, is not to be overlooked, for it is a constantly increasing piece of land not yet left by the working hand of creating nature, and therefore a matter for observation of much interest.

The muddy sheet of river water covers the whole view seaward before its mouth, when there is not any wind or current setting against the natural flow of fresh water; but if south or north winds are prevailing, the muddy tribute of the Rio Bravo, instead of spreading out into the open sea, and commingling there undisturbed with the salt waters, is checked and pressed aside as a long narrow strip along the beach in the direction that the wind sets the current.

Considering these circumstances, it is therefore clear that the place of deposits, both of the sea and river, gathering about the mouth are kept in a continual and also somewhat regular motion.

Among the regular changes to which the bar is subject, the most important is that caused by the annual rising of the river, which occurs during the months of July, August, and September. By means of this increased fresh-water power the deposits are carried and kept further out at sea, perhaps as much as a mile from the mouth. During the rest of the year the bar again approaches the beach; the oscillatory action of the salt water prevailing for this time, it is scarcely half a mile off the mouth of the river. The hydrographical distances between the bar and the mouth may be found on map No. 1, in the archives of the Department of the Interior.

Besides these regular changes, others occur monthly and daily that depend on the prevailing winds from the seaside, or meteorologic influences of the country above, not including many accidental occurrences which usually escape the scrutiny of the common observers. Of the latter kind are the depositions of drift-wood, or even wrecks and pieces of timber, which, after being washed ashore and left for awhile, are apt to form the foundation of a small bank or bar. Other more perceptible causes are seen in the stormy weather raging upon the sea and in the hurricanes on land.

These agencies, incessantly at work, all tend to one result, no matter how different their form of action may be, that is, addition to the land. The ebb and flow of the tide, the current of the river and sea, though often acting in opposite directions, only collect and again distribute the various material brought together by both fresh and salt water along the beach, where is presented by these gradual accessions the now forming and youngest portion of the continent.

The operations of all these forces may be altered or varied by extraordinary influences that may occur at any time, as they have done in ages past, such as the change of river beds in the alluvial regions, the closing of the mouths of the river, and the opening of other outlets.

There is not much doubt that the Rio Bravo once had its main mouth far from its present locality, no matter how powerful the descent of its waters to the sea must have been in all time.

Boca Chica, as its name implies, may be considered, without question, as one of the outlets of the Rio Bravo, which has thus contributed to the formation of Brazos Santiago and Point Isabel.

The currents over the bar of Brazos Santiago pour in a channel of such force against the tide as to corroborate the inference that a still greater fresh water flow than that of the Arroyo Colorado, some 25 miles to the north, comes into this bay. A glance at the course of the lowest portion of the Rio Bravo leads to a similar conclusion, for it has a decided inclination to the northeast after reaching the lowest portion of the colluvial belt.

It may be that the persons who attempted several years ago to dig a canal from the third bend (above its mouth) of the river, towards Boca Chica, or Brazos Santiago, may have had similar ideas on this subject.

We have thus dwelt almost two long on the formation of the bar; but however inconsiderable this matter may appear, it is still highly important to know the agents by which restless nature is achieving its work, the more so as the very same powers, now augmenting the land from the seaside, have, in all human probability, been contributing to this end for ages. It really seems beyond question that these oscillatory motions of the waters with the sweep of the gulf stream have deposited during the various ages of the cretaceous and perhaps tertiary sea that sediment along the foot of the bold Sierras, which at the present day form the western and northern limits of the now cretaceous basin of the lower Rio Bravo.

Taking also into consideration the parallelism of the easternmost of the Sierras of Mexico and the sinuosities of the Gulf Coast, there cannot be any mistake as to the relation of the one to the other. The various cretaceous terraces of the lower Rio Bravo basin, placed, as they are, one above the other, appear in this position as so many antediluvial tide-marks of that vast sea ; on the bottom of which secondary and also tertiary formations have been deposited, together with all those fossil types of organic forms—each genus and species belonging to its respective geological day.

Like the tide-marks that are arranged in large concentric circles, and that have been brought about by the oscillatory motions of the waters, the organic remains (leaves in the mighty book of the history of creation) can tell each one a tale of the physiographic condition of the age during which it rejoiced in the functions of life.

Whilst the currents and other forces of the water, acting horizontally, placed the different strata along the foot of the ancient coast of that *secondary sea*, a vertical force was needed to bring the submarine strata above the level of the water. If there were no signs of such a power, we could be content in believing that since the formation of the submarine strata the salt water has receded. There is evidence, however, that does not admit any question of the upheaval of the country. The volcanic dyke before spoken of is the strongest evidence in favor of this conclusion ; these basaltic strata projecting through the cretaceous, and generally, also, a part of the older secondary formation, have caused a rise in the whole of the cretaceous system. Thus the peaks and branches of this dyke naturally became the *caryatida* of the great geological edifice of this country, often bearing detached portions of the cretaceous strata far above their general level.

GENERAL VIEW OF ORGANIC REMAINS.

With regard to the fossil remains of the regions of the lower Rio Bravo, which have come to our knowledge, there are many among them common to the cretaceous formation of New Jersey. With this locality they are also quite synchronous, according to Mr. Conrad, who has examined them. The specimens of this character are mentioned in his enumeration of genera and species. Many of these fossil remains, however, seem to belong solely to the cretaceous formation of Texas, and are more particularly referable to the southern portion of the secondary strata, which, on their part, are also nearly allied to analogous forms of the cretaceous formation of southern Europe, especially that part lying about the Mediterranean.

To go here more into the details of this supposed relationship between the southern and northern cretaceous formations of both hemispheres is not the design of these pages. To such of our readers, therefore, that may be desirous of examining this matter further,* we would refer them to Dr. Roemer's work, already mentioned, which contains well-founded hints and proofs on the subject.

Besides the before mentioned interesting specimens, so important to the knowledge of the general distribution of fossil forms, several new species have come to hand which seem to be indigenous to the cretaceous formation of Western Texas. The enumeration by Mr. Conrad shows, so far, six new species. Since then, however, another set of organic remains has been sent on for examination ; and it seems to be not improbable that still other new forms may be met with in this collection of ours, the second made on the lower Rio Bravo. It is probable that some of the specimens of this last set will prove the prevalence of fossils of the tertiary system, which may

* For a full exposition of this subject, see Dr. Hall's report, which concludes the Geology of the Boundary.

be more developed in the lower portion of the lower green sand belt. This, however, is a mere suggestion to point only to the regions where data may be sought for; by means of which the distribution and limits of an eocene, and, perhaps, even pleistocene formation could be recognized.

We had not the opportunity to make such an investigation. It therefore devolves on some other person to continue the researches necessary to a complete understanding of the subject, and to the advancement of science in general.

CHAPTER III.

GEOLOGICAL FEATURES OF THE RIO GRANDE VALLEY FROM EL PASO TO THE MOUTH OF THE PECOS RIVER.

By C. C. PARRY.

Having completed our general sketch of the external features of the country, as represented on the line of route in nearest connexion with the United States and Mexican Boundary Survey, we now retrace our steps, to detail more particularly the course of the Rio Grande, especially in its connexion with the extensive cañons by which its course is marked, above and below Presidio del Norte. In these we gain insight into the geological structure of a large and interesting scope of country, also connected with scenery unsurpassed for singularity and grandeur.

About 70 miles below El Paso the mountains on either side of the valley converge, and present a lofty barrier in the direct course of the Rio Grande.

Through these the river makes its way by deeply-cut chasms, exposing the geological formation and structure in the sectional faces presented by its precipitous walls.

We also see in this connexion the lower limits of that extensive aqueous deposit, forming what may be termed the *Great El Paso Basin*, which, by subsequent drainage in the progressive deepening of the bed of the Rio Grande, has brought to view the various terraced elevations marked along the course of the present valley in table-land bluffs and extensive gravelly plateaus.

In fact, in our progress down the river we shall have constant occasion to notice the connexion between these cañons, as marking the limits of upper basins of deposit. Thus the general course of the river represents a continuous series, in descending steps, of basins, more or less extensive, then a cañon, forming, as we may say, the *spout* of the basin, which again opens on a basin of lower level.

This simple statement embodies the great principle of formation that characterizes all this district, and gives to its topography a significance at once clear and instructive.

It is in these *barriers*, then, these *mountain dams*, that the character of the valley, as a whole, can be best studied, and the chasms by which the river pierces them furnish the true key to their geological development.

That portion of the Rio Grande thus marked by cañons and basins, extending from the first obstruction 70 miles below El Paso to Presidio del Norte, did not come under my own personal examination.

The river here follows a general *southeast* course, making its way through strata of disturbed carboniferous limestone, having usually a dip to the *southwest.* The river course thus cutting the strata unequally, we should naturally expect not so much of a continuous cañon as an unequal development of rock on either side, presenting, it may be, bold and abrupt faces on the one side, and comparatively low on its opposite, thus affording the means of following near the river banks, by crossing from one side of the stream to the other. This, indeed, seems to have been the course pursued by the surveying party, with their pack-trains, who were thus enabled to keep up a connexion with the line of survey.

We should also expect, as another consequence of this irregularity of feature in the rock exposure, not such a marked contraction of the river bend and channel as we should be more apt to find in the case of horizontal strata of equal development; rapids would be less apt to form, and lines of beach would be more frequent. Further on, in encountering the exposures of igneous rocks, these features would vary, and here would be the points characterized by greater obstruction to the regular course of the river, and also rendering a passage along its banks more impracticable.

Such are the general features, as well as they can be gathered from the maps of the survey and the geological features of the country through which the river here passes.

Approaching Presidio del Norte, the valley of the Rio Grande again opens upon a wide basin, closely resembling in all its external features that seen above, near El Paso. The table-land, however, attains a greater height above the river bottom, presenting steep bluffs, often 200 feet high. The river bottom is also more contracted, rarely attaining a mile in width, and frequently reduced by the adjoining table-land to a mere strip. The river spreads out, embracing in its course numerous islands of deposit, and forming frequent sloughs along its main banks, subject to regular overflows. It is to these several tracts, islands, and sloughs that cultivation is chiefly confined.

On the Mexican side the Rio Grande receives the waters of the Rio Concho, flowing from the southwest, and draining a large extent of country in the State of Chihuahua. This is the only constant tributary to the Rio Grande yet met with in our course downward; its waters at the usual height are clear, flowing generally over a bed of limestone pebbles.

The delta formed at the junction of this stream with the Rio Grande affords a patch of soil suitable for agricultural purposes, and is occupied by the Mexican settlement of Presidio del Norte. The town itself occupies a conspicuous site, on high gravelly table-land, overlooking both valleys.

On the American side, about three miles below the junction of the river, the greatest amount of bottom-land suitable for cultivation is met with; it is connected with the site known as Fort Leaton.

The bottom-lands in this vicinity are variously occupied by scattering growths of cotton-wood, willow, &c. The highest alluvial tracts are covered with a dense growth of mezquite; the table-land presents its usual desert vegetation.

The natural boundaries of this basin consist of irregular mountain ranges, composed principally of carboniferous limestone, similar to that seen above. As a general thing, the strata here appear less disturbed, but show not unfrequently a strong westerly dip.

In an east and southeast direction lies the range of igneous mountains called the "*Sierra*

Rica," forming the topographical limits of the basin in that direction. Through this range the river passes, and forms here the first of a series of gigantic cañons below.

There is no occasion to dwell longer on the general features of scenery connected with this Presidio del Norte basin. To apply the term *Rio Grandeish* would convey at once a clear idea to any one at all acquainted with the general aspect of scenery invariably connected with this desert stream.

This first cañon commences about twenty-five miles below the town of Presidio del Norte.

The general course of the river for this distance bears south 70° west, (*mag.*,) passing at several points rocky knolls of igneous character which abut on the river. On approaching the mountain range directly in front, it will be seen that the river, winding through the lower line of adjoining hills, suddenly contracts its channel, and thence tumbling over a series of foaming rapids, enters the mountain range.

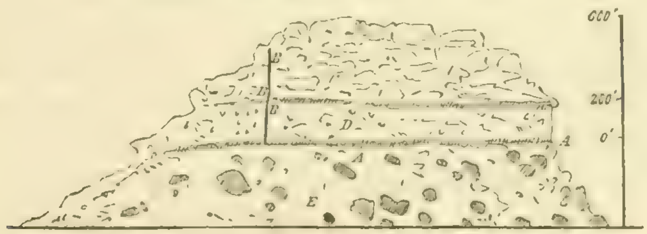
The rock exposure here is of a most remarkable character, and different from any heretofore met with. When the adjoining mountains, reaching a height of 1,000 to 1,500 feet, present a clear sectional face, we see a somewhat regular series, composed of lavas, vesicular or compact in texture, alternating with thick deposits, of an earthy form, of volcanic breccia.—(Specimen Rocks, No. 59 to 62 inclusive.)

The general arrangement of these formations shows them to be variable in thickness, and disposed in regular strata one above the other.

The dark-colored lavas form usually the upper capping, together with one or more intermediate seams. The intervening lighter colored breccias are often of considerable thickness, showing in some places a development of 300 feet or more, while at other points it is reduced to a thin seam. The usual appearance of these breccias is that of an earthy-stratified deposit, varying in color from a whitish brown to a dull green; its texture is more or less crumbling, being composed of a whitish paste, which contains, occasionally, minute pebbles of quartz rock.

In entering into the composition of mountain masses, these several formations assume very distinct and peculiar characters. Thus, where the earthy breccias are considerably developed, we see them exposed, along the sides of mountains, in perpendicular walls, capped by the darker colored lava rocks, which are frequently seen overhanging and forming a regular line of terraced platforms, thence rising upward in broken ledges to form a flattened summit. This

SECTIONAL VIEW OF BUFASILLA MOUNTAIN, NEAR THE COMMENCEMENT OF THE CAÑON OF THE RIO BRAVO, THIRTY MILES BELOW PRESIDIO DEL NORTE.



A. Lower exposure of trap-rock of closer texture than the upper stratum.

B. Vein of trap, six feet in thickness, traversing the intervening breccia formation, and connecting the upper and lower strata of igneous rock.

C. Vesicular trap-rock, dark colored, 400 feet ? thick.

D. Volcanic breccia in horizontal strata of light brownish color, 200 feet thick.

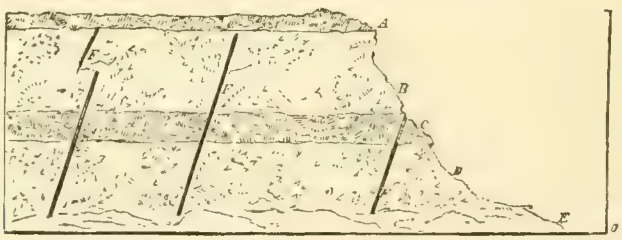
E. Talus strewn with blocks derived from the upper igneous stratum.

singular character of formation has given the name of "Bofecillos" to some of the more striking mountain ledges.

Owing to the crumbling nature of this underlying stratum, we find it variously washed and often fantastically shaped by the peculiarities connected with its various exposures; it thus frequently forms burrowing caverns and dark grottos, set off with misshapen pillars. Quite invariably we find its base occupied by a talus, derived from the overhanging rock, forming a rough slope strewn with irregular blocks; thus its connexion with the underlying rock stratum. This connexion is, however, occasionally brought to light, and shows a lower development of lava rock, differing but little from that above, except in a greater closeness of texture, the upper capping being generally vesicular, while that below is compact.

Frequently, however, a direct connexion between the separate lava strata is made by narrow dykes, identical in character with the rock above and below, passing through the intervening breccia. At other places, veins are seen shooting from above and below, and terminating in the intervening series.

SECTIONAL VIEW, SHOWING A SERIES OF VOLCANIC PRODUCTS, TRAVERSED BY INJECTED IGNEOUS VEINS; CAÑON OF RIO BRAVO, THIRTY-FIVE MILES BELOW PRESIDIO DEL NORTE.



A. Dark-colored vesicular trap.
B. Volcanic breccia of a lightish brown color in horizontal strata.
C. Lava or trap-rock of close texture, dark-colored.
D. Breccia as above, having a light greenish color.
E. Igneous veins.

We are now sufficiently prepared to appreciate the external features of the region thus characterized. We can understand how the unequal development of these several layers may give shape and character to the mountain ranges, and what diversified features they will necessarily assume, under the influence of denuding causes, acting so unequally on their separate members. The geological formation seems to conspire with the atmospheric influences to give a ruggedness and character of desolation to this region, of which description can give but a most meagre idea.

It is, however, in the line of the river-course that these rugged features present their grandest developments. We see the turbid waters of the Rio Bravo here contracted to a narrow channel, barely a stone's throw across, sweeping on a resistless current beneath bristling crags; now tumbling over foaming rapids, connected with some abrupt turn in the course of the stream, and then gliding smooth and unbroken through mountain clefts with perpendicular walls on either hand, rising to the dizzy height of 1,200 to 1,500 feet perpendicular.

In our progress through the range, the breccia deposit becomes less developed, and finally disappears altogether, or is seen only in narrow seams along the sides of the mountains.

The course of the river at first is not entirely hemmed in by abrupt rocky walls, a rough talus at the base affording a rude pathway, occasionally lined by narrow strips of sand beach.

At other places, however, all approach to the river, except by the route of its dangerous channel, is out of the question.

Along the course of the river, the mountain barriers are occasionally pierced by side chasms for the drainage of tributary mountain valleys. One of these is so remarkable as to deserve some separate notice.

At a point about seven miles from the entrance of the cañon, where the river is completely hemmed in on each side by the largest development of the mountain range, being unapproachable except in boats from above, there is a cut-off on the American side, leading by an open country over a gentle swell of ground, reaching the river about five miles below. This cut-off passes directly at the base of the high mountains intervening between this route and the river, having an average breadth of half a mile. At the summit of this swell is a depressed valley, the drainage of which leads directly toward this mountain barrier in its course to the river.

In following the dry-stream bed thus marked out, we find it entering by a narrow portal, about 15 feet in width below, thence cutting its way by a uniform cleft through the entire breadth of the mountains to reach the Rio Grande.

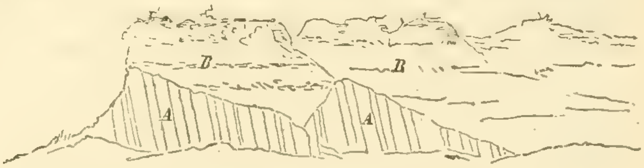
It thus presents a miniature picture of the larger cañon made by the Rio Grande. Its floor shows a smoothly-washed rock surface, in which basins frequently occur, bedded by washed sand and pebbles, and receiving the limpid issue of a small trickling stream. In its general course toward the river, it makes frequent zigzag angles, thus giving a new feature of scenery at every turn, and presenting altogether a most varied combination of the grand, grotesque, and beautiful. Along its sides is plainly observed a high-water mark, with an average height of 15 feet above the rocky bed, indicative of the sudden floods, derived from copious rains, to which this chasm is subject. This fact serves to give a somewhat nervous interest to its exploration. The height of the perpendicular walls on each side, corresponding to the thickness of the mountain range, is from 300 to 800 feet. The chasm thus formed opens up gradually towards the summit, forming a broken yawning abyss, untouched by sunlight, and having its depth exaggerated by the comparative dimness that shrouds it below.

Thus sheltered from the sun's scorching rays, and cooled by evaporation from its brimming basins of clear water, with its entrance fanned by a constant stream of cool air, this cañon forms a grateful retreat. Further toward the river the descent is made by several abrupt falls, forming extensive basins below. These are filled with clear water, and offer natural bathing places of a most attractive character. Its exit on the river presents the same general features of chasm, the final *debouchment* being marked by a *débris* of rocks and pebbles, which project into the main stream and form a difficult and dangerous rapid.

About three miles from this latter point, and twelve from the head of the cañon, the main development of the mountain range forming the Sierra Rica is passed ; the final exit is through a narrow rocky portal, and presents the appearance of an immense gateway. The width of the river at this point is barely 80 feet ; the adjoining mountain ridge on either side is so broken and rugged as to be impassable for animals.

On passing this narrow outlet we come upon a more open but still broken country, consisting of basins of limited extent, set off with the usual form of gravelly table-land. The course of the river is frequently obstructed by low rocky ranges, forming cañons ; again pouring out of these cañons into the more open basins, it becomes expanded, and forms limited sand beaches, patches of bottom-land, and occasionally small islands. This character continues for ten or twelve miles, when we enter on a more extended basin, through which passes the Comanche trail, leading from Upper Texas into Mexico, by the adjoining Mexican settlement of San Carlos.

SECTIONAL SKETCH AT COMANCHE CROSSING, ON THE RIO BRAVO, BELOW PRESIDIO DEL NORTE.

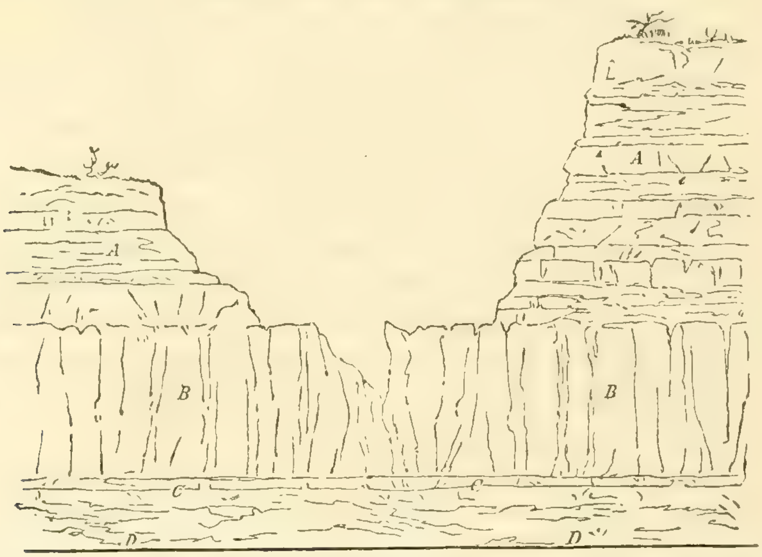


A. Cretaceaus limestone marked with large ossils of Inoceramus, inclining N. N. E., at an angle of 80°.
B. Mesa, or gravelly table-land formation, resting unconformably upon A.

At this point the rock exposure exhibits outcrops of limestone belonging to the cretaceous period, being quite abundantly marked by fossil impressions of *Inoceramus*, often of large size. The rock exposure exhibits a very variable dip, mostly inclined towards the west, occasionally at a very sharp angle. It rises at various points in the adjoining table-land, forming ochreous colored rocky bluffs, where at several points the gravelly table-land is seen to rest unconformably on the sharply-tilted strata.

Further down the river, in an eastern direction, this cretaceous formation assumes a nearly horizontal position and a closer texture. It is here seen overlaid by a variable sheet of dark colored lava rock, corresponding in character to that noticed above in connexion with the Bofecilla mountains. This sheet of igneous rock is seen to conform closely to all the inequalities

SECTIONAL VIEW ON A RAVINE LEADING TOWARD THE RIO BRAVO DEL NORTE, NEAR SAN CARLOS, SHOWING IGNEOUS ROCK DIRECTLY ASSOCIATED WITH CRETACEOUS LIMESTONE.



A. Cretaceous limestone, having an earthy texture, containing fossils of Inoceramus, 150 feet.
B. Dark-colored igneous rock, 80 feet in thickness.
C. Cretaceous limestone of closer texture than that above, 15 feet thick.
D. Debris.

of the underlying limestone, exhibiting in the walls of the cañon below a distinct line of separation, traceable for a long distance. The westerly dip of the cretaceous formation underneath gradually thins out this upper igneous capping, which finally disappears, and solid limestone walls continue along the line of the river.

At one point on the line of the trail leading round the broken ranges of the mountain ledges, directly bordering the river, to reach its bed some eight miles below the Comanche Ford, the sides of a deep washed ravine bring to view the successive and relative thickness of the various exposures alluded to above.

We here see the upper members of the cretaceous rocks forming the tabled summits of the adjoining mountains, and marked by frequent cretaceous fossils, resting on a bed of igneous trap-form rock 50 to 80 feet thick, this again overlaying the closer layers of the limestone strata below.

Our further route, adjoining the river on the Mexican side, passes over high ground, based on limestone rock, and attaining a height of 800 feet or more above the river, the strata here dipping slightly to the west. We again reach the river-bed at the mouth of San Carlos creek, which, draining a considerable valley extending to the south some fifteen miles, affords a constant stream of clear water.

Just below this point commences the gigantic cañon of San Carlos, through which for ten miles the Rio Grande, pursuing a nearly due east course, makes its way. This cañon presents unbroken walls of cretaceous limestone.

The course of the river here cutting the strata in a line directly opposed to the dip, there is a

FALLS OF RIO BRAVO, NEAR SAN CARLOS.

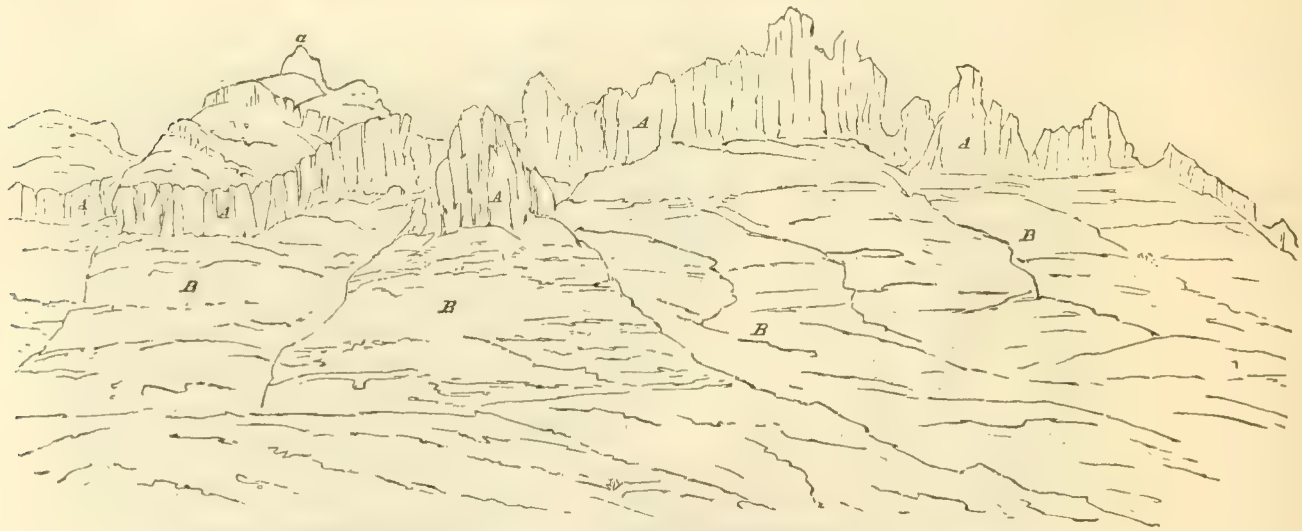
constantly increasing elevation of the cañon walls. These walls commence with a height of between 200 and 300 feet; but the fall of the water combined with the rise of the strata, develops, in the course of ten miles, a clear perpendicular height of at least 1,500 feet above the river level.

A faint conception only can be formed from these facts of the truly awful character of this chasm. Its course can be marked along the mountain slope in a regular zigzag line, terminating by an opening cleft, which rises high and clear above the surrounding mountain ranges.

The surface of the ground adjoining the river bank is a slightly broken slope, extending to the east, and showing a continuous development of the range to the north and south. The general surface presents no indication of a river course, and you are not aware of its presence till you stand suddenly on its abrupt brink; even here the running water is not always visible, unless advantage be taken of the projecting points, forming angles, along the general course of the river. From this dizzy height the stream below looks like a mere thread, passing in whirling eddies, or foaming over broken rapids; a stone hurled from above into this chasm passes completely out of sight behind the over-hanging ledges, and one can often count thirty before the last deadened splash announces that it has reached the river bed. From the point formed by its last projecting ledges the view is grand beyond all conception. You can here trace backward the line of the immense chasm, which marks the course of the river, till it emerges from its stupendous outlet.

Below this the country presents from a bird's eye view an extended basin, set off by the rugged volcanic mountains of the Chisos, we trace the winding of the stream in the basin below, to which distance gives a softening character of fertility not by any means borne out on a nearer inspection.

OUTLINE VIEW OF THE CHISOS MOUNTAINS, LOOKING TO THE NORTH.



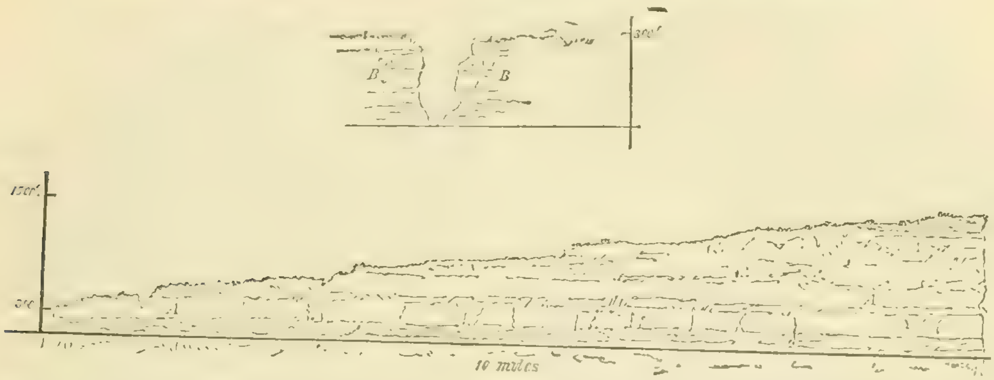
A. Dark-colored igneous rock of vesicular or close texture, disposed in vertical columns or horizontal masses.
B. Volcanic breccia in evenly horizontal strata, light-colored and of crumbling earthy texture.
a. Emory's Peak, 2,500?'' above the waters of the river, having the appearance of a crater.

Rumor had led us to expect, in connexion with this chasm, an extensive river fall, but such did not prove to be the case. Rapids, indeed, do occur sufficiently severe to render a safe passage by boats a virtual impossibility, but no distinct fall from an upper to a lower ledge of rocks was encountered by the surveying party. Indeed, from *a priori* reasoning, we should hardly expect to find such a feature in this location, where the strata are of such uniform texture, and where the evident marks of such long continued abrading forces tend to level the river bed.

All the rapids seen along the course of the river are connected either with a talus, thrown down from the projecting cliffs, or with the irregular deposit brought down from the beds of tributary streams.

Within this cañon there is rarely a foothold visible along the line of the ordinary water level, and at no place for the whole distance of ten miles would it be practicable to make a safe descent to the water's edge, still less to ascend. The "*facile descensus*" would here be truly "*Averni.*"

SECTIONAL VIEW OF THE GREAT CAÑON OF THE RIO BRAVO DEL NORTE, NEAR SAN CARLOS.



A. Perpendicular walls of limestone rock, having a gentle dip to the west, giving increased height to the walls of the cañon, along the eastern course of the river.
B. Cross section of the cañon, showing the general shape of the chasm. (Same scale, horizontal and perpendicular.)
Note.—For 300 read 800.

It would be barely possible, in a time of high water, to conduct a boat safely through this stupendous chasm. A strong wooden boat, which accomplished the entire distance from El Paso to this place in the service of the survey, being here cast adrift, was found in broken fragments along the river course below. There are rumors among the Mexicans living near here of the attempted passage of this cañon by some daring individuals, but no authentic record of a successful result.

A perpendicular cross section of this cañon exhibits a rather peculiar feature, at least such as is not noticed elsewhere: thus, instead of a regular slope or perpendicular descent of the cañon walls on either side, we have an expansion of the breadth of the cañon at two distinct points, above and below. The vertical cross section would thus correspond to that of a pitcher, showing first a flaring top, then a contraction, and again bulging out below; the peculiarity consists in this lower expansion, but is evidently susceptible of a ready explanation. Thus, it may be regarded as due to the irregular action of river flood and recession, acting along its pent-up course in such a way as to exert a greater denuding effect on the sides of the chasm than on its lower bed.

Professor Hall has suggested that such a shape would be apt to result, in such situations, from the gradual diminution of the body of running water, naturally connected with increasing land elevations.

The average width of the stream within this cañon is probably about 100 feet; and when we come to include herein the immense floods that in other places spread out the river overflows for miles, we can appreciate its terrible energy when pent up within such narrow limits.

Sufficient has, doubtlessly, been said on this most remarkable feature in the course of the Rio Bravo; its details, however, will have a general application to what is to succeed, and render a more elaborate notice of the successive cañons unnecessary, all of which resemble the above in general aspect, but none equal it in extent and grandeur.

In order to reach the lower basin in the course of the Rio Grande, beyond the San Carlos cañon, you have to make an extensive detour, and pass again up the San Carlos creek about ten miles to the "Old Presidio of San Carlos." This now deserted adobe structure is situated on the eastern side of the valley, occupying gravelly table-land, and overlooking the alluvial bottom, which shows the remains of former cultivation in extensive lines of irrigating ditches. The cultivation carried on by the present inhabitants of San Carlos is confined to the upper part of the valley. These cultivated fields extend some five miles, and present a rich belt of alluvial soil, abundantly watered and consequently fertile.

On leaving the San Carlos valley, we pass by a southeast course over an upland, gently undulating plain, set off by occasional rocky knolls, and encircled by mountains mostly of volcanic formation. Our course thence, inclining more to the northeast, leads over broken swells of the limestone range pertaining to the cañon above described. Thus, by a series of steep descents, the lower basin of the Rio Grande is gained at a point some distance below the mouth of the San Carlos cañon, and nearly opposite the range of the Chisos mountains.

The general character of the valley here presents the usual features of gravelly table-land, flanking a narrow alluvial belt along the winding course of the river. The bottom-land here is again bordered by cotton-wood and willow growth.

Towards the exit of the river, from the San Carlos cañon above, the general aspect of the valley is modified by irregular outbursts of eruptive trap rocks, confusedly alternating with volcanic breccias.

The general course of the river through this basin is easterly; the bottom-land is of limited extent, and generally barren. At several points here are seen Indian fords and broad trails leading from upper Texas into Mexico. These beaten paths are unmistakable indications of the route pursued by the Camanches on their extensive foraging expeditions.

These routes, both to the north and south, are comparatively open, and are apparently determined by the depressions that occur in the elsewhere uninterrupted line of mountains.

The continuation of our land route down the river compelled us to cross, with our pack train, at one of the Indian fords called "*Vado Fleche*," thence taking along the Texan side to turn the spur of the mountain range forming the San Vincente cañon.

This range is exclusively composed of cretaceous limestone, similar in texture to that in the San Carlos cañon above. It differs from that, however, in being of less height and extent, and in showing, in place of a regular western dip, a distinct anticlinal axis, the dip being quite abrupt on either side. Cretaceous fossils, identical with those found at San Carlos, serve plainly to characterize this formation.

The cañon of San Vincente is very abrupt and of considerable height; the ridge adjoining is also very broken, exhibiting steep descents and branch chasms, which rendered the survey extremely arduous. The passage through this cañnon was accomplished by our India-rubber boats, one of which was, however, capsized in shooting a sharp rapid. On emerging from this range, the Rio Grande opens on the San Vincente basin, in which, on the Mexican, side is situated the now deserted Fort San Vincente.

This basin differs from all others yet seen in being exclusively formed of low ledges of a dark-colored stratified rock, showing low bluff ranges 30 to 50 feet high. These ridges have a very uniform dip of 15° to the northeast; they occupy in great measure the place of the usual gravelly table-land, forming along the *line of strike* open valleys. Arid and bleak sterility characterizes this formation, to which the scant and sandy bottom-land is hardly an exception.

Fossils are occasionally copiously imbedded in these ledges; among which principally *Ostrea*, *Ammonites*, and *Turritella* occur, and show that the formation belongs to the upper cretaceous series. At some points there is an evident approach to the lower Tertiary formation.

VIEW OF PRESIDIO DE SAN VINCENTE AND SIERRA CARMEL

The eastern limits of this basin are marked by the extensive and elevated range of the Sierra Carmel, presenting directly in front an unbroken wall composed of a light-colored limestone. This shows a dip to the east. Its western aspect exhibits a line of perpendicular escarpment rising in several peaked knobs to a great height. The line of mountain wall thus exposed presents a series of terraced elevations, dividing horizontally the abrupt face of rock exposure.

Along these terraced lines, and associated with the talus there accumulated; is a growth of dark-green shrubbery, strongly contrasting with the ochreous-colored wall, which forms the background.

This mountain range further to the southeast exhibits an extensive development of igneous rock, showing in the distance a very rugged outline.

The occurrence of these several ranges forces the river from its east and southeast course, and gives it an abrupt turn to the north. The mountain barrier is thence passed at a lower elevation of the main range forming the *Carmel cañon.* The river here cuts through the limestone strata, showing a distinct dip to the northeast; after a course of 8 miles, the river emerges on the eastern slope of the Carmel range. To accomplish the same distance with our mule train a detour of 40 miles was necessary, leading again to the river at the point where it emerges from the mountains. The operations of the surveying party being here suspended, our route hence led southward to the Mexican settlement of Santa Rosa, thence to Eagle Pass.

The eastern slope of the Sierra Carmel shows the strata of cretaceous limestone inclining eastward at an angle of about 20° ; its exposed face is variously marked up by irregular trenched valleys and abrupt points and ledges, due to the natural denuding forces of water drainage and atmospheric action. This slope terminates in an irregular valley below, having its drainage to the north, and leading direct to the Rio Grande. Further south is conspicuous the extensive igneous development of the mountain range, rising in jagged peaks to an Alpine height, and presenting in the forest growth, which clothes its sides, agreeable features of verdure, contrasting strangely with the river valley and its bare outline of desert hills.

The most northern outlier of this igneous formation is the singular peak known as the "*Picotena.*" Lying at a distance of about 5 miles from the river, it rises abruptly from amid the surrounding limestone ranges, shooting up a sharp conical peak of basaltic structure. This peak, by its height and external features, presents a most striking landmark.

The country stretching to the north and east in the course of the river is less interrupted by high mountain ranges than has yet appeared on the line of our route, and presents features precisely similar to those before noticed in connexion with the lower valley of the Pecos. Igneous exposures disappear altogether, or are of very limited extent, and the limestone strata are but little disturbed. The numerous deeply cut valleys leading to the river are bounded by abrupt walls, rendering travelling, except in the direct line of their drainage, next to impossible. In attempting to follow down the river with pack animals, the only practicable course was to follow up to near its head one of these tributary ravines, thus reaching the general table summit, and then to pass over to and down another ravine leading to some uncertain point of the river below. By this plan it not unfrequently happened that, in order to make a distance of 5 or 6 miles by the line of the river, a detour of 30 miles or more was necessary. Each of these detours, moreover, leads over a country destitute of water, except the uncertain rain water retained in rocky wells, which generally occupy positions inaccessible to animals.

This character of country continues hence uninterruptedly to the mouth of the Pecos river, about 80 miles distant, presenting great uniformity in the general external and geological features of country.

Our course led along the eastern base of the Sierra Carmel, bringing to view, in connexion with its larger development of igneous formation, a section of country extremely picturesque, including well watered valleys, timbered mountains, and upland plains covered with a luxuriant growth of nutricious grass.

Indian traces abound in these vicinities, and the deep recesses of the adjoining mountains afford secure retreats, where the animals plundered from the Mexican settlements are driven to recruit, in preparation for their passage across the Rio Grande into Texas.

To this character of country again succeed ranges of cretaceous mountains, showing a general easterly dip of strata, and connected with upland basin plains mostly waterless.

At a distance of about a hundred and fifty miles south from the Rio Grande we reach a system of elevated basins, having frequently a drainage distinct from the valley of the Rio Grande, forming extensive inland lakes fed by numerous rivers. The noted *Bolson Mapimi* is the largest example of this lagoon formation.

Several, however, of these lagoons on the northern edge of this elevated area give rise to tributaries which empty into the Rio Grande. Of this latter class, the "*Laguna Agua Verde*" is an example. Along the line of one of these valleys last mentioned our route led, thus threading our way through the mountain barriers, forming the northern line of the Santa Rosa range, thence emerging on this charming valley a short distance above the town of Santa Rosa.

The route thence to the Rio Grande at Eagle Pass is over an open country, occupied by low swells of cretaceous limestone, thus merging into that character of country pertaining to the region of central Texas.

For further details of the lithological character and fossil contents of the various rock exposures above alluded to, reference may be had to the lists of Mr. Conrad and Professor Hall. A very interesting paper from the latter gentleman also contains important generalizations, derived from examination of the various geological specimens collected in this and other expeditions.

The numerous illustrations of scenery from various sources will supply all that can be desired in regard to the general aspect of the region under consideration.

CHAPTER IV.

GEOLOGICAL OBSERVATIONS ON THE COUNTRY ALONG THE BOUNDARY LINE LYING BETWEEN THE 111TH DEGREE OF LONGITUDE AND THE INITIAL POINT ON THE RIO COLORADO.

[By Arthur Schott, Assistant U. S. B. C.]

Geographical terms for this section of the boundary line would be Sonorian or Pimerian, as it runs through the northwestern part of Sonora, which also bears the old Spanish name of Pimeria Alta (High Pimeria ;) and since it intersects both meridians and parallels in an oblique direction, it is called, in geodetic language, "azimuth line." This line lies entirely on the eastern slope of the basin of the Gulf of California, and falls on *the divide* separating the waters of the Gila from the streams of Northern Sonora, which, after flowing in a southwesterly course, empty into the Gulf of California.

The hypsometrical and general geological features can only be expressed approximately, for circumstances prevented actual measurements.

At the eastern end of the azimuth line is the Sierra del Pajarito, from the highest point of which an imaginary line drawn to the Rio Colorado would give a grade of about 22 feet to one mile, or its equivalent, 0.41 to 100. The highest point may be set down at about 5,200 feet above the level of the sea. This point does not, however, reach the pine region, which in this latitude may be considered as occurring at an elevation of not less than 6,000 feet. A monotonous simplicity is a characteristic of the topographical features of Northwestern Sonora ; and but for a close examination, there would only be disclosed a mere dualism of diluvial drift and pluto-volcanic mountains. The drift covers many of the mountain ranges almost to the tops, particularly those which approach the bottom-lands of the Colorado.

The northwestern part of the line runs over what may be called a veiled country ; for of the mountains, only their crests are to be seen above the desolate sand-flats of the general level of the surface. It is through these forsaken barrens that the Rio Colorado, with its timbered bottom, winds its course towards the waters of the Gulf.

Comparing the geological edifice with the structure of animal organism, the mountain ranges jutting up through this vast level of drift represent the skeleton ; the diluvial main the sinew and muscle ; and the alluvial deposits the tegument or epidermis. The last mentioned is poorly represented. The scant vegetable cover facilitates, however, the observations of the geologist.

Alluvium is seen first and as the uppermost stratum ; except at the extremities of the line, there is, however, but very little to be met with. As might be expected, it abounds most in the bottom-lands of the Colorado ; but, strange to say, it is even in greater abundance on the highest mountains than on the plains. It frequently collects in such quantity in the little valleys and in the cavities of the broken sides of the mountains as to give rise to a more complete development of vegetable life. The plains exposed to the drifting sand as well as to climatic severities are almost wholly deprived of an alluvial coat. A few traces may be looked for at the so-called "Playas," (depressions in the plains.) What little rain may fall collects here, and bringing down with it the lighter particles of the surrounding soil, affords a foothold for vegetation, which presents, however, more a mass of equals than a diversity of species and genera. Often, apparently, this premature effort of nature to develop vegetation is sadly counterbalanced by the saline character of the soil, which causes the prevalence of corresponding forms, as obione, salicornia, salsola, chenopodium, and others, in the place of algarobia, prosopis, or even salix, the usual types in analogous localities.

The plains lying between the mountain ranges are formed of a more or less uniform deposit of loose diluvial sand, its composition not differing essentially from that of the adjoining mountains. This diluvial main may, therefore, be called the debris of the adjacent mountains and of the underlying ma s.

As to the formation of this diluvial main, we incline to the opinion that it is the residue of a sea once a connecting link between the waters of the Atlantic and Pacific. Changes in the constituents of this deposit certainly occur; but they are of a local character, besides having a certain uniformity. Fragments of quartz, mica, feldspar, and other similar elements of crystalline and igneous rock, associated with calcareous particles, constitute the formation of that vast region of deserts stretching from the eastern foot of the California Cordilleras to the table-lands bordering even the Rio Bravo. This section of country may thus be viewed as the bed of an ocean variously intersected by numerous reef-like or dyke-shaped mountain ranges.

In the immediate vicinity of the mountains, isolated beds of pebbles are sometimes seen, the lithological character of which indicate their origin. These pebbly beds, however, must not be confounded with similar ones occurring occasionally about the centre of the desert basins and frequently along the dry water-courses. The former are the disintegration of the rocks, unmoved from their original locality, whilst the latter are gatherings of an immense area. The latter bear evidence of being brought from the most opposite and most remote geographical quarters; pieces of limestone representing both the carboniferous and cretaceous periods with tertiary and even traces of lime recently precipitated; these fragments are mingled with agate, chalcedony, semi-opal, opal, jasper, slates, silicia, breccias, and crystalline and amorphous conglomerates; here, also, are silicified, agathized, or opalized fragments of wood side by side with pieces merely incrusted—scarcely metamorphosed or entirely unchanged, and of quite a recent geological date; semi-opal, formed entirely of shell, whose age is readily recognized by the numerous nummulites associated with it; agate, with neat fragments of encrinitic or coraline forms; jasper or hornstone, which, under a common lens, discloses both the texture and grain of coniferous wood; opal, exhibiting traces of the structure of fossil-wood, with distinct annular concentric rings, but no marks of the grain could be detected; glass-opal, and hyalite, containing casts of some forms of the coral age pisolites, in appearance like a toadstone, which are either unchanged or metamorphic. The deserts of both sides of the Colorado and along the Gila abound with these pebbly beds, surrounded by and occasionally entirely buried in the sand. To the scientific observer they are pearls of this vast terrestrial ocean, which once formed the bottom of a sea, whose currents in all probability collected these pebbly deposits. Since the water has receded, an ocean of a more subtile character sweeps over this area. Ærial currents are now driving the shifting sand from place to place as the waters of the sea once did.

Besides the general inclination of the western slope of the Sierra Madre towards the Gulf of California, an increased inclination of stratum is perceptible around the bases of the intersecting sierras. This does not, however, affect the mean ascent of the main land, and may be ascribed solely to the deposition of debris, as the angle formed by the inclination of the diluvial deposits was observed (particularly in the valley of the Santa Cruz river) to be $= 2.5^\circ$.

The general ascent already referred to is conclusive proof of the action of upheaval forces since the deposition of the quaternary or diluvial drift. A straight line over its surface from the valley of the Colorado to the foot of the Sierra del Pajarito, where it ceases, gives a grade of 12.44 per mile, or 0.23 ft. in one hundred. In some valleys heading on the slopes of this sierra this deposit may be seen; but its occurrence in such localities being exceptionable, does not affect the mean angle of inclination of the stratum.

The height to which this diluvial main rises, in its approach to the Sierra Madre, gives a striking peculiarity to the features of the country. But for it the rugged crests of the sierras would be scarcely accessible.

If the climatic conditions were favorable, these now bleak and forbidding mountains would present a region teeming with vegetable and animal life. Instead of that, this country now lies an arid waste.

The few periodical streams descending from the mountain sides share a similar fate, for no sooner do they reach this drift than they disappear from the surface, sinking to unknown depths, and leaving only in the vicinity of the mountains slight marks of rudimentary drainage, clumps of shrubbery bordering dry water-courses.

The vegetation peculiar to the diluvial main is similar to that of the corresponding localities on the eastern side of the Sierra Madre and west of the Colorado. Besides smaller and more inconspicuous forms, are the Larrea, Fouquiera, Obione, and other chenopodiaceous shrubs; there are also a variety of leguminous plants, numerous members of the Cacti family, and some few bushes and trees, all well known to the traveller whose fortune has led him through these desert regions.

In passing to the consideration of the underlying strata—those upon which the diluvial deposits rest—a deep step is made at once; constituents of the secondary age seem to be wanting. Crystalline rocks of primary and transition age—more or less metamorphic—constitute the bed upon which the diluvial deposit lies. This bed does not occur as an even or slightly inclined plane, for its surface is variously broken by eruptive masses. These upheavals have not only disturbed and protruded through the primary and metamorphic strata, but carried with themselves masses of the latter above the level of the supercumbent deposits. Thus are formed the mighty sierras now representing the frame-work of our geological edifice, most of which may be distinguished as Pluto-volcanic.

With the hypsometrical features of these sierras, better called cordilleras, three important peculiarities are connected. These are, 1st. Parallelism among themselves, with the Gulf of California, and with the Pacific coast. 2d. Articulation. 3d. General petrographic relationship.

The parallelism is a fact now better understood than the natural laws which effected it. The linear extension of the axis may be supposed to be the result of electro-magnetic forces combined with the action of tidal currents, together with other causes, such as isothermal, isoclinic, and isodynamic currents. We offer the following explanation, founded on our own observations: After the first formation of the dykes and reefs composing the sierras, the result of volcanic forces, acted upon by electro-magnetism, sedimentary strata commenced to be formed. The igneous forces, however, at this time prevailed, and as a consequence, the strata of that era exhibit a crystalline character. By the increase of volcanic detritus and sedimentary material, the igneous ejections were confined to certain fissures only, whilst the action of aqueous forces became more general. The crust thereby becoming more and more firm and overlaid, the molten masses had to seek other outlets, determined, perhaps, by the character of the sedimentary rocks through which they led. To the stratification, lamination, and cleavage of the sedimentary rocks, as determining the subsequent direction of these volcanic forces, we may ascribe the formation of the catenary mountain ranges and dykes, and the cellular system of their intermediate bases.

The mountain ranges are mostly one-sided upheavals of metamorphic strata; the dykes, on the contrary, are essentially volcanic eruptions. The two classes of mountains are seen in a diversified combination of volcanic, plutonic, and aqueous or sedimentary rocks; syenitic and granitic lavas; trachyte and trap still exhibiting clear traces of lamination, cleavage, and stratification; granite, gneiss, syenitic, and various transition slates. How far this view may agree with the observed geognostical data, the special survey will show.

Before entering on this subject, we propose some remarks on a few Spanish terms which define their objects with a precision that could hardly be otherwise arrived at except by much circumlocution. These words are—

Cordillera, which means a long, continuous range of mountains, composed of several ridges, sometimes united by cross spurs, and intersected by passes or narrow valleys. The essential characteristic of this word is, that it means a mountain composed of two or more ranges forming one orographical body, just as several strings twisted together make a cord. The words cord and cordillera are formed from the same stem.

Sierra, a saw, indicates a mountain range with a serrated crest. A cross section of either sierra or cordillera is very small compared with its longitudinal axis.

Cuchilla.—This signifies a branch or outrunner of a sierra, which it usually resembles in its physiographical character. Its sharply edged crest, in all probability, suggests its name—cuchilla meaning knife.

Picacho means a sharp peak rising conspicuously above a surrounding mass of mountains; its height bears the same proportion to its width that the longitudinal axis of a sierra does to its cross section.

Puerto—a gate, or gap, and also a post. In its topographical application, a pass over or through a mountain range.

Cañon implies a defile or mountain pass without any outlets on either side.

Loma is a long mountain, or ridge of hills, with a somewhat smooth and flat surface. *Lomita* is the diminutive form of the same word.

Mesa is a table-land, table-mountain, or a flat-top ridge. *Mesilla* is the diminutive.

Malpais—literally, bad land; the "Mauvais terre" of the French. In Sonora it is exclusively applied to mesas, lomas, or any more or less elevated plateau formed of igneous rock, here mostly a compact or vesicular trap or basalt.

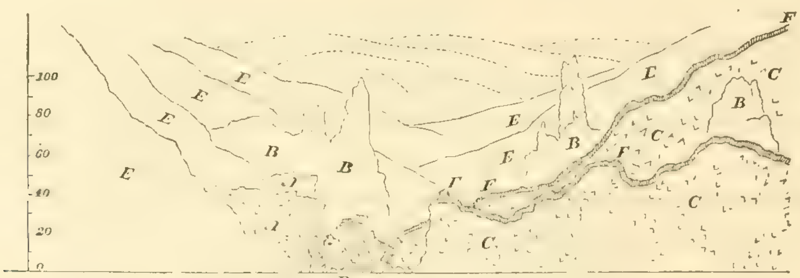
Ciēnaga is a valley, or depression in a plain, where the water collects, and can only escape by an obstructed outlet. Such a place is usually miry and boggy.

Charco means a hole in clay, or stratum of rock, where water collects, and from which it cannot run.

Tinaja is a water-hole, found in the crevices of rocks and ravines, difficult of access. The primary meaning of this word is an unglazed earthen jar, burned so as to allow exudation. The water thus oozing through evaporates and keeps that remaining inside cool.

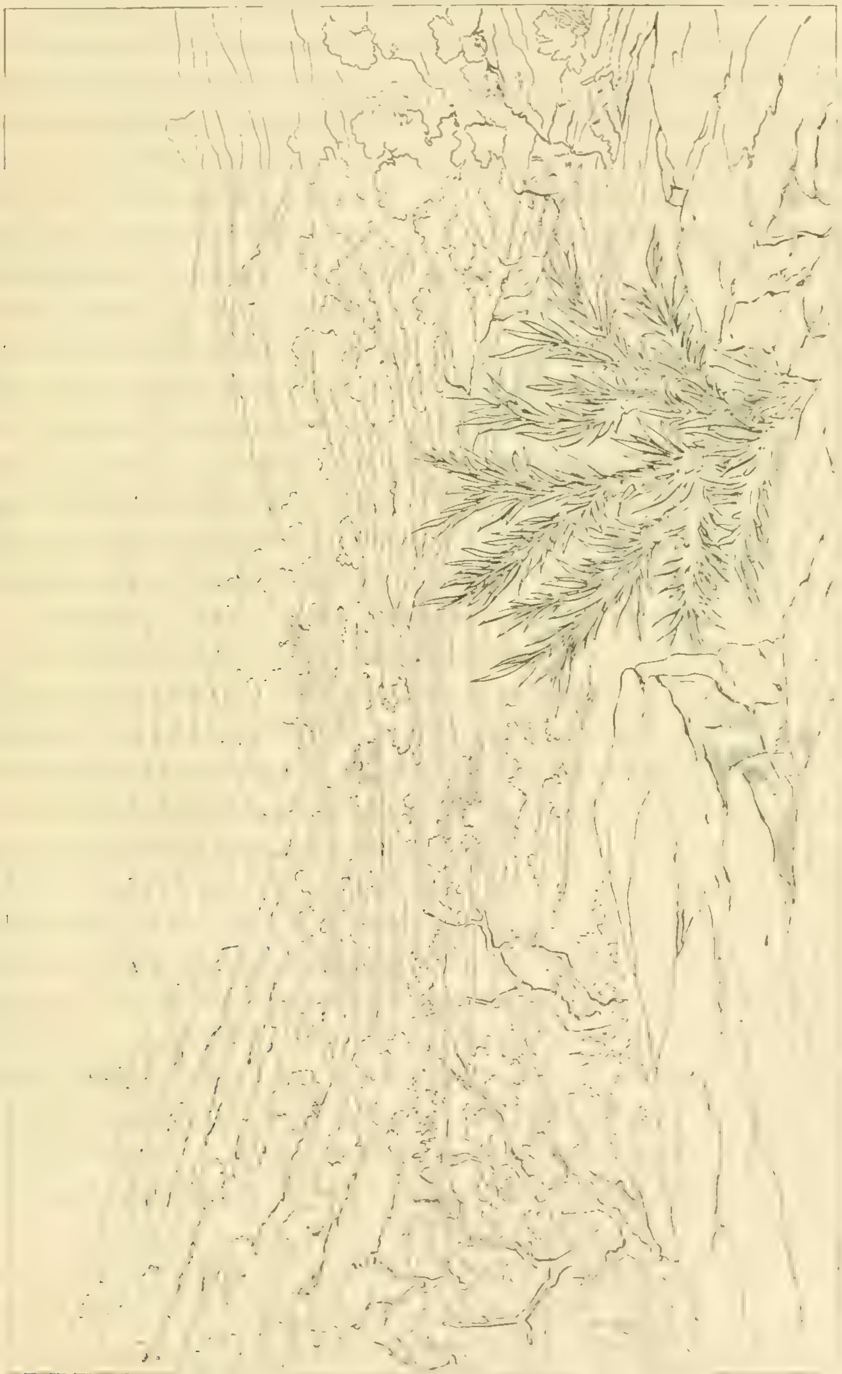
Beginning at the intersection of meridian 111° and parallel 31° 20′, we proceed to the consideration of the various sierras crossed by the line.

The Sierra del Pajarito (little bird) shows crystalline transition rocks, metamorphic and unchanged; also, trachytic strata, or metamorphic forms of granitic and syenitic rocks, (E.) Some of the more elevated portions exhibit a rough cellular surface, whilst the lower are smooth and more compact. The tint is light pink, or flesh color. This rock contains much glassy feldspar, and, occasionally, particles of augite, indicating the frequent occurrence of a syenitic granite. A fine-grained, white, metamorphic syenite, consisting of minute particles of hornblende and white feldspar, occur on some of the cuchillas on the north side. On the lower parts of the west slope talcose (argillaceous) and quartzose slates are met with, though trachyte dykes range through in every direction; in the bottom and slopes of the valleys the igneous rocks prevail. In one place a solid mass of trachyte is cut through by an arroyo, forming a puerto, flanked on both sides by vertical walls of eruptive (A and C) rocks fifty feet thick. The mountains on both sides slope towards this gap at an angle of 35 to 40 degrees. Here, and other localities along the foot of this sierra, pudding stone, volcanic breccia, feldspathic porphyry, and trapitic amygdaloid rocks abound. Some of the water-beds are lined with a singular formation, (B,) and apparently of a later age than those just mentioned. At first sight it may be considered a fresh-water deposit, overlying or placed alternately with volcanic breccia.



SECTIONAL VIEW OF THE VALLEY DE LOS JANOS.

Occasionally traces of stratification, and even cleavage, are visible, especially in its upper part; its lower portion is cemented into a solid mass. Its color is a light brown, or dark ash-gray. The outer crust looks as if it had been subjected to a process of calcination, for it readily crumbles or exposes a marl or chalk-like substance that could be easily scratched out with the finger. There were no means at hand to identify this as carbonate of lime; yet we were inclined to the belief that the whole mass of apparent fresh-water deposit was cemented by this material, which also formed the matrix of the volcanic breccia. The trapitic and amygdaloid rocks (F) appeared everywhere, no matter how great the elevation, slightly blended with carbonate of lime, as if it had been precipitated there by water. This calcareous precipitation was espe-



VALLEY OF "LOS NOGALES."

cially perceptible in the vesicular cavities of every trachytic or basaltic boulder, and also in the fissures of the rocks and in the dells where these latter are imbedded.

On the east slope, in the valley of "Los Nogales,' (Walnuts,) similar strata line the various water-courses, sometimes forming a continuously winding low bank, or terrace, on both sides, and sometimes covering the slopes of the adjoining mountains, composed of metamorphic rock.

On the hill-sides there are beds of this formation dipping towards the valley, and exhibiting, by decurrent, undulating lines, a shaly, laminated texture. On the easternmost limits of this valley the same formation is still more developed; and it can be seen in all the valleys to the south and southeast of the Sierra de Santa Barbara, which is a part of the cordillera embracing the Sierra del Pájarito. The volcanic breccia, in many of the ravines, form walls of from forty to fifty feet in height, varying from an angle of forty-five degrees to perpendicularity. Pieces of this breccia, heated in a log fire, and then thrown into cold water, showed much effervescence, without fracture.

North and northwest of this mountain range, bearing east and west, the Sierra Janos rises up in bold terraces of dark-brown amygdaloid trap and porphyry, the broader terraces being nearer the base. These gigantic shelves are bordered with rocks projecting out in the most fantastic shapes. They incline toward the main body of the sierra—deep and lateral valleys intervening. A huge block, exhibiting on its south and west side gigantic walls, with distinct stratification and cleavage intersecting at right angles, constitute at once the centre mass and the peak. The rectilinear fissures are visible at a distance of ten or fifteen miles, and giving the igneous walls more the appearance of mason-work than the result of volcanic action.

This sierra's vernacular name, "Janos," bears no reference to its petrographic character. The word signifies, in the language of the Papago Indians inhabiting this country, an arborescent shrub of the bignoniaceous order, belonging to the genus "Chilopsis." Its frequent occurrence here in the water-beds in this vicinity may have originated the name.

On the northern slope of the Sierra Janos another group of mountains occur, known as the Sierra Atascosa. Its bearing is the same as that of the Sierra Janos, and its longitudinal axis is common to this sierra and that of Sierra del Pajarito. All these three links of the cordillera have both dip and strike alike, the dip being to the east. Its petrographic character is similar to that of the Sierra Janos, and, being closely connected orographically, may be considered its twin. The cordillera formed by these three mountains terminates with the Sierra Atascosa, which is separated by a narrow and rugged valley from the Sierra del Babuquibari, lying to the northwest. This valley is of some importance, not only for its valuable fresh-water springs, but also as affording the only means of communication between the settlements of the Santa Cruz River valley and the coast regions along the Gulf of California. A rancho was once established at these springs, bearing the Papago name of Aribaca, or, more properly, Aribac. The settlement has, however, been abandoned long ago, in consequence of the repeated depredations of the Apaches. The northwestern part of the sierra is composed of igneous rocks, towering up into peaks of the most grotesque form, and bearing, not inappropriately, the name of "Malpais."

Atascosa means "miry," which probably has reference to a previous state; it now presents the appearance of being an upheaved, boiling, volcanic pool. This sierra and that of Janos have about the same elevation above the Santa Cruz valley.

Springs abound about the Sierra del Pajarito, but their drainage being, for the most part, below the surface, it requires a well-practised eye to detect their presence, particularly during the dry season, which occurs in April, May, June, and sometimes July. There is a considerable development of vegetation on this sierra; the rough surface of its sides is covered with a dense growth of shrubbery, of which some are quite trees, and grass is luxuriant in all the valleys. There are several species of oak, and on the summit is found a cedar; though this ridge does not fully reach the pine region. This sierra partakes of all the physiographical features of the Santa Barbara, Santa Cruz, and other links of the Sierra Madre further east. The Sierra del Pajarito, with its dependencies already referred to, constitute one and the same mountain system, properly characterized by the word Cordillera, and, taken collectively, are known as the Arizona Mountains. This word probably belongs to the soft Papago language, but we could not learn its meaning. The Arizona Mountains are rich in silver, copper, and gold; evidences of numerous and well-worked mines are still to be met with. The eastern slope of the Sierra del Pajarito (Los Nogales) is especially worthy of exploration with reference to a development of its mineral production. Specimens of silver from this locality were analyzed, and the result will be found in its proper place.

The Sierra del Pajarito constitutes a part of the divide already referred to, and has been intentionally dwelt upon at length for the purpose of referring the other sierras to it as a standard of comparison in consequence of its typical character, both as to its hypsometrical and geological features.

Looking westward from the peak of the Sierra del Pajarito, a rugged net of mountain ranges is spread out, made up of metamorphic rocks; and though the single sierras do not rise very high, they form a very bold mountain relief by the close, uninterrupted texture of the inclined plane which constitutes them. (See outline sketches Nos. 34 and 35 of the azimuth line.)

At a distance of about sixteen miles another cordillera is visible, between which and the Sierra del Pajarito very little drift occurs; and this is confined only to the intervening valleys, where mesas and lomas, forty to fifty feet in height, are formed by the drainage from the surrounding mountains. Near where the drainage from the east slope of the Sierra de la Escondida joins that coming from the southwest side of the Sierra del Pajarito, a point just south of

SECTION ON THE NORTH SIDE OF THE CERRO DE SONORA.

the line, permanent water is to be found. It is under a cleft of igneous rocks, and does not properly deserve the name of a spring, but is rather a tinaja supplied by water trickling through the rocks from water-holes above. From the character of this place is taken the name Escondida, (agua escondida meaning hidden water,) a term which is generally applied to the whole sierra. In its orographical character, this sierra is but a volcanic dyke,(A) towering up into an isolated, rugged crest of igneous rocks, composed of amygdaloid, porphyritic, and trachytic compounds, intersected and overlaid by contorted and overthrown crystalline strata of a coarsely-grained and frequently disintegrating feldspathic syenite(B.) This syenite is sometimes metamorphic, at other times unchanged; sometimes it is quartzose, and imperfectly mixed with large scales of silvery mica, in other places feldspar prevails.

This sierra is scarcely more than one mile wide where the line crosses it; both sides are bordered by the upheaved and contorted crystalline beds just alluded to. We ascended to the top of this sierra, near where the singular-looking peak that marks the Escondida towers up, and found it to exceed in barrenness either of the sierras—Pajarito, Janos, or Atascosa. Portions of the terrace-like slopes, and also the plateau, are covered with patches of white or pearl-colored chalcedony, investing the rocks with a scoria-like crust of that silicious fossil. The southern part exhibits a more horizontal arrangement, leading to the supposition of having been formed under water; for here are extensive table-lands, ridges, lomas, and mesas, composed partly of black vesicular or compact trap, and partly of real quaternary banks. The topography of the country seems to indicate here the confluence of numerous mountain streams and torrents coming from every direction. (See sketch No. 40 of azimuth line.)

The line crosses a little to the north of a conspicuous peak(D)—the highest point of the whole range—and falling on the Mexican side, we gave it the name of "Cerro de Sonora."

Immediately west of the Sierra de la Escondido a low group of granite hills(C) occur, furnishing several temporary, as well as permanent, water places, apparently well known to the natives—Papagos and Apaches. Some are mere tinajas; others real springs, though liable to become dry before the setting in of the rainy season. While encamped here we experienced a heavy hail and thunder storm; in a few minutes water came rushing down the ravines in a torrent, five feet deep, carrying everything before it, and giving us unmistakable proof how little time it requires to submerge all the valleys around under a most terrible flood of rain-water. This mountain group was called "Granizo," (hail,) and is so designated in the maps from the circumstance of the surveying parties being overtaken here by one of those hurricanes peculiar to these regions.

A flat valley, nine miles wide, separates the Sierra de la Escondida and the adjoining Granizo group from the Sierra Verde, which is a southern spur or branch of the Sierra del Babuquibari, north of the line. The plateaus bordering the dry water-courses of this valley furnish fine grass, and are sparsely covered with well-developed hackberry and liveoak. The Sierra Verde, so called because of the verdure encountered in the shelter of its rocky valleys, seems to be formed exclusively of feldspathic granite, similar to that already mentioned as occurring on the east slope of the Sierra Escondida. The strike-side faces southwest, and with a width of scarcely more than a mile, this sierra does not present any petrographic novelties. Its longitudinal axis ranges southeast and northwest, and joins the bold walls of igneous rocks belonging to the Sierra Babuquibari. At its southern end mounds of dark, vesicular trap crop out of the diluvial main. Here water finds its way to the surface, forming a spring known as the "Pozo Verde," (Green Well;) the bunches of rush, which at once conceal and mark the water, in all probability gave rise to the name.

Almost due north of the Sierra Verde lies the picacho of the Sierra del Babuquibari, which is one of the orographical phenomena of the country, its peculiarity being such as to attract especially the attention of the red man. The Papagos consider this huge mountain obelisk their palladium; here they take refuge in times of famine, drought, or war. Babuquibari is said to signify "water on the mountain." The word is certainly formed from babu (water) and ari (rock or mountain.) Its great height, added to its spire-like top, causes it to act as a conductor to the clouds, and thereby gather an unusual quantity of rain, which is retained for a long time in its numerous rugged and inaccessible recesses. (See outline sketch No. 39, azimuth line.) Viewing the country westward from the Sierra Verde, a wide plain is visible, bounded at a distance of fifteen miles by a mountain range traversing the country with the invariable bearing southeast and northwest.

The eastern half of this plain is favored with a more than usual cover of vegetable life—abounding in grass, a dense growth of brushwood, and mesquite; the western part, a low flat, was entirely destitute of vegetation, which seemed to have been destroyed by small trogloditic quadrupeds of the order *Rodentiæ.* Although this plain had received copious showers of rain a few days previous to our visit, singularly enough no life was given to the naked and barren flat. A change, and not to its advantage, is here perceptible in the physiographical features of the country, and becomes quite decided in the next mountain range, which is unlike all the sierras eastward, and which presents an isolated group rising out of the diluvial main.

Notwithstanding its lesser extension, the Sierra de la Union presents no peculiarity in its petrographic character—being a compound of igneous and metamorphic rocks. The latter constitutes the greater portion. On the east slope feldspathic granite in a disintegrating and somewhat metamorphic state occurs; on the west is a quaternary granite, similar to that mentioned as occurring on the Sierrita del Granizo. The backbone or central mass is formed of igneous amygdaloid and porphyritic rocks, here and there overlaid and concealed by crystalline strata.

Thus far there has been but little room for the diluvial deposits, so broken up is this region by the continuous succession of mountain ranges; but westward, great basins of quaternary and alluvial deposits form the main in which the sterile mountains lie imbedded and completely isolated by this vast sea of drift. Of the sierras ranging eastward, parts of them are so entirely submerged as to appear detached and isolated mountains, their connexion being traceable only by their general bearing. The country passed over may be viewed as a narrow strait, traversed by long mountain reefs, and that, in part, as a coast of shoal water dotted with rocky islands. The influence of the climate of the Gulf coast, as far as the Sierra de la Union, is quite apparent; on its west slope two leguminous trees, the Palo verde and Arbol de hierro of the Mexicans, Cercidium floridanum and Olneya Tezota, three large Cerei, two gigantic Echinocacti, and other desert forms, now appear in prevailing numbers.

The line, after crossing a desert of about seventeen miles, strikes a comparatively low and narrow sierra, composed chiefly of porphyry and amygdaloid rock. This sierra presents two vertical peaks, rising up like a pair of horns, which constitute natural monuments for the line as it falls between them. It is a northerly continuation of the Cordillera Cobota, so called by the Papago Indians, who have several fixed settlements here. There is a cañon in this sierra, near the line by which the west side is easily gained, and in which are seen masses of crystalline rock; igneous strata, however, prevail. The name "Lindero" (boundary or landmark) was given to this sierra, because of the line falling between the two conspicuous peaks before mentioned.

The sierras Arteza and Soñi lie, respectively, southeast and northwest; the former in the United States, the latter in Mexico, both well known and famous among the natives as being remarkably auriferous; especially Soñi, once a mining settlement of the Mexicans. It was abandoned at the time of the California gold fever. The latter subsiding, the old settlers, disappointed on the Pacific coast, are now returning again. The Papagos claim this region, and, from the time they first learned to appreciate the value of gold to the present day, have continued to prospect successfully.

A desert of sixteen or eighteen miles in extent separates the Sierra de los Linderos from that of la Nariz. Though these sierras are nearly related in petrographic character, there exists one striking difference. The former is, at least where it was crossed, a true volcanic dyke, bordered in some places by upheavals of crystalline strata; its crest of eruptive rocks seems to have been forced through a mass similar to itself. The latter, though consisting also of trachyte and trapitic masses, appears only a simple upheaval; its crest, comparatively smooth, is the upturned edge of a bed of igneous masses, dipping northeast; its strike faces the west, at an angle of 60 to 70 degrees. The surface (B) of the east slope is covered with a thick layer of loose boulders, of a black or dark-brown vesicular trap. On the strike, stratification (A) is visible, even at a considerable distance, the layers varying in thickness from five to twenty-five feet.

VERTICAL SECTION OF THE SIERRA DE LA NARIZ.

This sierra ranges in a slightly curved line from southeast to northwest, and joins about eight miles north of the line the Sierra del Ajo, of which it is, in fact, only a spur. A little to the north of where the line strikes, quite a depression occurs, the range here not being more than fifty feet above the drift.

A valley of about fifteen miles wide separates the Sierra de la Nariz from the Sierra de la Laguna on the north. Its petrographic character seems to be similar to the de la Nariz, having the same strike, dip, and stratification. Trap mounds accompany both sierras, cropping out along their bases to a height of thirty or forty feet above the level of the valley. There are no springs to be found about any of these mountains; holes of water or ponds, (charcos and lagunas of the Mexicans,) formed in beds of clay, are the only dependence for water, and are not to be relied on during the whole season. The surveying parties being unexpectedly fortunate in finding an abundance of water here, the sierra was called La Laguna (de la Esperanza;) it seems but an eastern branch of the Sierra del Ajo.

Northwest from the Sierra de la Nariz this latter sierra, a bold and high mountain range, is visible. As we have been told, it takes its name, (del Ajo,) garlic, from its structure, appearing as the consolidation of various branches forming a cordillera. Although composed most probably of volcanic rocks, similar to that of ranges just referred to, it is quite different in its other features. As seen from the southwest, a huge central block of metamorphic, or, more probably, igneous rock constitutes the strike side. This block, exhibiting traces of horizontal stratification, is divided into two almost equal parts by a protruding mass of rocks, which, though lithologically almost the same, show a vertical columnar structure instead of a horizontal stratification. On the sides and about the base numerous isolated and volcanic peak tower up, but they all, undoubtedly, have the same origin. The main body of this sierra, resembling the bulbous head of garlic, has been dignified with the name of that plant. This rather hyperbolic comparison appears somewhat justified, as it refers also to the endogenous

SOUTH SIDE OF THE SIERRA DEL AJO, AND PART OF CIÉNAGA DE SONOYTA.

growth of both the sierra and the garlic. It forms a subdivide, but the separated waters unite before they are lost in the waste of sand along the Gulf coast.

A wide valley spreads out from the west foot of the Sierra del Ajo; being hemmed in on all sides by mountains, and having only one (and that somewhat obstructed) outlet, this is designated, in Spanish, as a ciénaga. As the sierra heretofore referred to strikes the eye with a dark-brown or even black aspect, on the other hand the sierras southwest, composed of metamorphic crystalline rock, (feldspar prevailing,) meet the view in a robe of glaring white, dazzling under the rays of a Sonorian sun. It is common to the traveller to distinguish these two classes of mountains as the *black* and *white*, so opposite is their general appearance. At the western foot of the Sierra Juchibabi, which bounds the valley on the south and near the old Mission of Sonoyta Chloritic slates and greenstone appear—these are, however, but local. A branch ranging north shows throughout the same light-colored feldspathic crystalline rock. The ridge east of the ciénaga is but a slight swell of the diluvial plains, and affords an open and travelled pass to Presidio de Altar.

Besides numerous deep charcos and even small lagoons in its lower part, this ciénaga is blessed with a small stream fed in its outset by a number of small springs. These springs afford a constant flow of water, which proves their deeply-seated source. The water is clear, of a bluish hue, but warm and slightly brackish. Notwithstanding this permanent supply, the little river of Sonoyta continues but about a mile as a running stream. There was a mission founded here, but it has long since shared the fate of all similar establishments of this desolate and remote region. The inhabitants now consist mainly of Papagos, who have a few miserable huts, and irrigate a small patch of ground.

The Sierra del Ajo, rising up at the northeastern corner of Ciénaga de Sonoyta, is remarkable for establishing, by a natural monument, a true boundary between the coast and the interior. In its northwestern continuation auriferous and argentiferous copper ores abound. The gold and silver product in this location is said to be sufficient to defray all expenses of mining and assaying, leaving the copper a net gain. These mines have been long known to the Papagos and Mexicans, but were not worked for want of capital and security against the Apaches. Some Californians, under the name of "Arizona Company," have now "prospected" the country between Sonoyta and the Gila. They commenced to build roads, make water-tanks, introduce labor, and, notwithstanding these initiatory expenditures, anticipate a prosperous business.

Following the bed of the Sonoyta river, a narrow but smooth pass leads to another ciénaga, which, having but little water, assumes the general aspect of the desert. The course of the Sonoyta river is traceable through it, but the water, except in two or three places, does not come to the surface, and it is necessary to dig for it everywhere during the dry season. Feldspathic crystalline mountains border also the ciénaga except on the west, where the river finds an outlet for the flood of water that may sometimes rush down its usually dry course.

The sierra partakes very decidedly, in its physiographical character, the features of the Great Colorado desert. It is a Papago name, and signifies little mountain gap or pass. Upon some rising ground in the west end of the last-mentioned ciénaga there is a settlement, or, more properly, cattle rancho, the inhabitants of which are favored with spring water flowing out in abundance from a dozen little springs. These springs come out in a line from a considerable bank, which seems to have been formed by sediment, perhaps carbonate of lime, which they themselves have precipitated. The water resembles, both in appearance and mode of issue, that of Sonoyta, and there would be in all probability no error committed in assigning their thermal and mineral properties to a common source. West of Quitobaquita the line passes over a broad ridge dipping east and west before reaching the Cerros de la Salada.

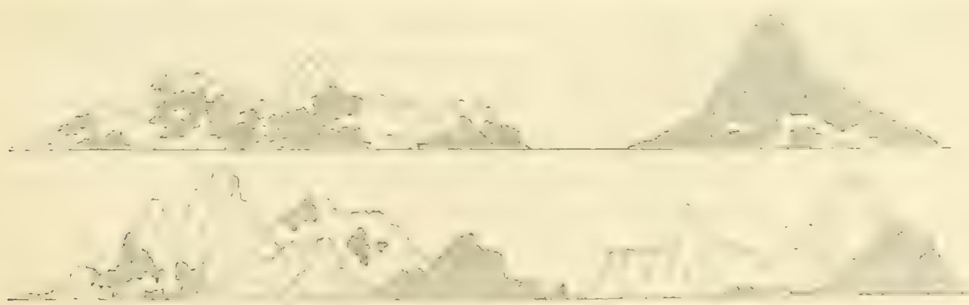
This group, like all the adjoining mountains, consists of crystalline feldspathic rock. The present structure of the Salada hills indicates a general geognostical disturbance of the relative position they must have once sustained. They vary in relative height, and the rocky parts are often covered with debris. The relative position as well as the direction of the sierras between this place and Sonoyta show a deviation from the parallelism so characteristic of northwestern Sonora.

The water of the Rio Sonoyta appears above ground for the last time near Quitobaquita. On the southeast side of the Cerros de la Salado fresh palatable water can be got in its bed by digging to a depth of about three feet. Just below, it becomes so salt that even famishing mules will not touch it. This salt water has given its name to the adjoining mountains. From this point southward the country is open, presenting to the view a bold and isolated mountain group at some distance, known as Sierra Pinacate. Its name, signifying beetle, does not seem to have reference to any peculiarity in appearance or formation. In consequence of the entire absence of water, the Sierra Pinacate is almost inaccessible ; it is, however, celebrated throughout Sonora for wonderful and inexhaustible layers of rock-salt, which is said to be stored up in immense masses, arranged in diversified strata and of a variety of colors. This Pinacate, in all probability, bears a close geological relationship to the Cerros de la Salada.

West of the Salada hills a wide, waterless desert stretches out, studded with numberless isolated little peaks and a variety of mounds, composed of the crystalline feldspathic rock or igneous masses—the latter is either trapitic, amygdaloid, or porphyritic. Southward, this desert is bounded by low ridges or, rather, gradual risings of the diluvial main ; north and west by bold volcanic sierras. A rugged cordillera, known as the Sierra Tule, limits this desert on the west, and breaks off what would be otherwise an uninterrupted continuation of the great Colorado waste.

There are playas near the centre of this desert plain, and sometimes just after a rain charcos of drinkable water. Towards the Sierra del Tule, there is an ascent over an immense bed of dark versicular trap, from which rise small black and white hills or mounds. These gradually increase in size and number in the vicinity of the mountains, and assume an elongated shape, with the usual bearing S.E. and N.W. Finally they unite with the latter, and form spurs of the main mountain mass.—(See outline sketch No. 58, of azimuth line.)

The black and white rocks which constitute this mountain appear in one place closely packed or pressed together ; in another they shoot up as separate branches. The dip and strike with the stratification and cleavage are contorted, and in most places entirely obscured ; at another



PLUTO-VOLCANIC PEAKS STUDDING THE MAL-PAIS EAST OF THE SIERRA TULE.

place again they are traceable even at a distance of a mile. This is a mountain block—the upheaved corner of a bed of feldspathic syenite or granite changed into granitic lava or regular trachyte, containing numerous large crystals of glassy feldspar. The singular aspect of this mountain is produced by the protusion of crystalline rocks through a bed of black vesicular trap.

The morphological features of these walls of rock bear a resemblance to the ice formations of the Polar seas. Similar causes have effected similar results; there, we have the consolidation of aqueous masses; here, the crystallization of pluto-volcanic rock. Similar in outline, there are, on the one hand, ice-fields, hummocks, packs, and icebergs; on the other, vast beds of trachytic lava, contorted peaks of porphyritic or amygdaloid rocks, upheaved edges of immense beds of metamorphic masses forced upon each other—broken, crushed, and shattered—and formed over again.

The whole of both the icy and rocky world, each one floating half submerged upon an ocean—the one upon the salt waters, and the other upon the residue of a quaternary sea. The moving medium is also somewhat analogous to the masses acted upon. There are the oscillatory movements of the sea with one, and the folding of the earth's crust with the other.

That metal is to be looked for in mountains like that of Sierra del Tule is doubtful. A piece of copper ore, however, was picked up by one of the party off one of the highest—almost inaccessible—peaks. Our duties were such as would not permit of an examination for ores of any kind; yet had their been any indications of their occurrence—such as oxides and sulphates of copper or lazur and malachite—they would certainly have attracted our attention. (For analysis of piece discovered, see page 25.) This, consisting like the last-mentioned sierra of several ranges, would be more properly called cordillera.

The petrographic features of these sierras are similar, and there is not much doubt but that they originated from a common upheaving focus. This sierra is the last of the ranges traversing the State of Sonora. Westward from its crest a few rocky peaks only are visible, rising out of the diluvial main like out-posted reefs along a seacoast, and are in all probability the tops of submerged sierras. The tinajas altas, or water-holes, in the volcanic crevices of this mountain are famous; they are the principal places in the surrounding country where the traveller between the Colorado and the springs of Sonoyta may expect to find water.

After leaving this sierra, the Colorado desert proper is entered upon, stretching in an unbroken sheet of drifting sand to the foot of the California Cordilleras, a distance of about 130 miles. The distance in a direct line from the Tinajas to the Colorado is about 45 miles; about midway, there is a slight swell of the sand traversing the desert, and which may be considered an underground sierra.

Reviewing the mountain ranges passed over, we find that they invariably dip to the east, with their strike facing west; each sierra and cordillera may, therefore, be considered as one page in the great book of creation. Few of them have been fully opened so as to permit a satisfactory reading of their pages; whilst their greater number still remain closed, with just one edge turned up. Our belief is, that when the time for further revelations come, the axis of disturbance will develop itself in the eastern base of the California Cordilleras, and these mysterious sheets will be turned from west to east.

The sierras Santa Cruz, Pajarito, and Santa Barbara, have disclosed a part of their geological history, while others, especially those on the confines of the desert, have hardly commenced to do so.

Earthquakes are not uncommon in the basin of the California Gulf. There are two solfataras now known at the eastern foot of the south California Cordilleras, both still in activity; and the lower Colorado is constantly changing not only its bed but also its numerous bends. Below the mouth of the Gila there is but one place where the river remains unchanged, which is so remarkable a fact that the navigators of this river named it the "Permanent Bend."

Considering such facts, we cannot doubt that the regions here spoken of have not yet passed through all the phases of their destiny. We do not, however, believe any general and violent catastrophe indispensable for further geological developments. A long continuance and perhaps imperceptible rising of the country, a simple increase of elevation, and especially an enlargement of the angle of grade by which the horizontalism of the quaternary main would be disturbed, should it become subjected to these forces, would aid the torrents of the mountains and the sweep of ærial currents to clear the surface of the country from its desert burden.

CHAPTER V.

PHYSICAL AND GEOLOGICAL DESCRIPTION OF THE COUNTRY FROM THE INITIAL POINT ON THE PACIFIC TO THE JUNCTION OF THE GILA AND COLORADO.

The data on which these results are based are derived from personal observation and collections continuously made during my stay in that region from July, 1849, to March, 1851. This period was variously occupied in different sections of this region, including an interrupted residence in the vicinity of San Diego ; an expedition of three months' continuance to the mouth of the Gila River ; a land journey up the Pacific coast as far as Monterey; a residence during the fall and winter months of 1850–'51 at the Mission of San Luis Rey ; together with various minor excursions to the mountains east, north and south of San Diego.

The region of country thus covered by my observations includes portions of territory lying between 32° and 36° N. latitude and 114°–121° W. longitude. The district, however, to which my attention was mostly confined is indicated on the accompanying geological map, and popularly known under the title of Southern California.

The separate heads under which I propose to embrace the general information pertaining to the subjects assigned me are—

I.—*The general physical features of country.*

II.—*Geology and mineral productions.*

III.—*Botany.*

IV.—*Agricultural capacities.*

I.—THE GENERAL PHYSICAL FEATURES OF COUNTRY.

The most marked external feature which serves to give character to the region under examination is seen in the occurrence of a mountain range parallel and in close proximity to the ocean, presenting in its various elevations and the differences which characterize its two slopes (eastern and western) a great diversity of scenery within a small compass of territory. The range itself, in its geographic relations, must be regarded only as an inferior link in the great mountain chain extending along the entire northwest coast to the extremity of the California peninsula. To the part at present under consideration the local but not very precise term of the Cordilleras of California has been applied.

Directing our attention to this portion of the mountain range, considered as a whole, it will be remarked that, while the general direction of the range is parallel to the coast, this feature is worked out in detail so variously that it would be difficult, from a single point of view, to decide on the true direction from noting the supposed axis of greatest elevation. This is, perhaps, owing to a peculiar feature of the range, which, instead of consisting of continuous ridges or *sierras,* as they are termed, are made up of an irregular series of rounded or ridge-formed peaks, sloping gradually towards each longitudinal extreme, with their more or less tapering spurs interlocking with those of adjoining ridges, but scarcely ever in a continuous line.

This view of the range will serve as a useful key to explain many of its peculiarities. Thus, as one fact in connexion with the general features of scenery, it will be noticed, that though the bareness of vegetation would seem to favor extensive views, they are seldom, even from the higher points, of that commanding character such as may serve to give a true idea of the elevation attained, or to strike the mind with those ideas of grandeur elsewhere connected with wide-spread mountain scenery. The horizon is, in fact, shut in, and the view confined to a limited sphere, by the varied direction of these mountain spurs. Roads and passes are also readily found, and routes can be modified with comparative ease by selecting the interlocking spaces to pass from one range to another, or by crossing spurs at their lower depressions.

Another fact connected with this character of the range is a marked tendency in the main valleys to assume a basin shape, apparently encircled by mountains, and fringed on all sides by branch valleys, affording a choice of travelling routes in every direction. We also frequently meet with upland plains of a similar character, where the more extended view takes in distant mountains, in which, though a more determined general direction of the range is apparent, the approach to a basin feature is not lost.

Connected with the same general cause, streams find their way by very devious courses, and on the western slope, particularly, are seldom followed in any direct line of travel.

In reference to the two slopes of this mountain range, an important point connected with their distinct external features is to be noted in the fact that the axis of greatest elevation, or the true divide, is much nearer to the eastern than the western base. Thus, supposing the mountains to have an average width of 60 miles, the centre of this line would invariably fall far on the western slope, the real water-shed being pretty constantly marked within ten miles of the eastern base, thus leaving a proportional difference between the length of the two slopes of five to one at least; hence, as a natural consequence, the eastern slope is more abrupt and precipitous, the western more gradual and circuitous; the streams of the former dash down a limited descent, and are soon lost in the absorbent debris at the base; the streams of the latter, flowing more leisurely, and drawing as tribute in their winding course a more abundant supply, frequently embody sufficient force to reach the ocean.

Confining the attention more closely to the Pacific or western slope, we are led to observe in its wider dimensions that it is made up of quite a number of parallel minor ranges, comprised in the general series, forming intervening depressions, and marked off by spurs, in the above-mentioned basin-shaped valleys; towards the summits these valleys are more contracted in breadth, and attain wider dimensions as you approach the coast. At the higher elevations, the mountain sides are usually bare and rocky, but the immediate summit assumes a more verdant character, being clothed more or less with pine and Alpine oaks. The ranges adjoining the coast are smooth in outline, slope up gradually into vertebrated ridges, and are covered with a dense, brownish shrubbery, giving a singular, smooth aspect to their distant outline. Moisture is more abundant and the streams more copious towards the higher elevations, while the wider coast valleys, unfed by perennial streams, are, during the greater part of the year, destitute of running water, the issue from occasional springs becoming speedily evaporated in the dry atmosphere.

These different ridges vary somewhat in geological structure, and, as we shall have occasion to notice hereafter, serve to give an additional variety to the mountain scenery. However viewed, nakedness is the prevailing character, the exceptions being few and far between.

The summit ridge, attaining a variable height above the sea of 3,000 to 5,000 feet, presents in its wintry covering of snow, and its richer verdancy of summer growth, some of the finer features of California scenery. Without possessing a marked Alpine character, it approaches it in a sparse growth of pines, and other coniferæ; while the frequent fogs bathing its sides favor the growth of lichens and mosses almost unknown in the lower regions, except in a few evanescent forms during the rainy season.

The view to the west takes in the bold outline of treeless ranges stretching in a dim line seaward. Looking towards the east, the less obstructed view traces the line of diminished vegetation, plainly and somewhat abruptly marked, in going downward on the steep slope. Irregular mountain peaks, and ranges of a dull, ashy color stand out in view in close proximity, and below all stretches the brown plains of the desert, extending to the hazy marked line of the Colorado river.

Descending from the summit westward, you pass down luxuriantly grassed valleys, edged with scattering pine and oak groves, and watered by cold, perennial streams, until an abrupt descent to a lower level brings you again into wider basin-shaped valleys, bounded on all sides by rocky ridges. The streams spread out into low grassy or sedgy marshes, and the pine growth gives place to the lowland oak, with its peculiar undergrowth. Continuing thus by a series of gentle swells and abrupt descents, you pass almost insensibly the different ranges, till the smooth, brown outline of the coast range indicates your proximity to the sea.

In the summer season you wind down broad valleys, marked by the dry, pebbly beds of winter streams; herbage is dry and wiry, and water confined to a few willow-shaded marshes or isolated springs. Opening on the sea, you traverse dry moorland hills, dropping down to the sea-level in the bed of some wide, sandy valley, which, with its sides bounded by precipitous walls of coarse sand and pebbles, finally spreads out into wide saline flats, cut up by tide estuaries, and terminates on the ocean beach.

Proceeding from the same summit ridge in the opposite direction (eastward) from its pine fringed heights and rich green sward, you drop by a steep descent into pent-up valleys bounded by ashy-colored mountains. The streams which flow in the upland ravines are soon lost in their thirsty beds. The valleys near their exit from the mountains slope in a regular plane, covered by wide and dry beds of streams. Occasionally the passage of an irregular mountain chain is marked by a rude defile, cutting through mica slate, or highly micaceous granite. Thus winding with occasional passages over ridges of the same character, flanked with rough pebbles, the desert opens before you, its table-land being generally gained by a steep ascent from the deep bed of some dried up stream, along the course of which the geological tertiary formation is strongly marked in thick layers of marl or sand, surmounted by a varying bed of rounded pebbles.

Over the desert waste, furrowed occasionally by the dry sandy beds of rain streams, you pass insensibly down till the lake formation of "New River" comes into view. Here the soil acquires a sedimentary character; fresh-water shells are scattered here and there. The immediate lake edges and lower depressions are bordered by a growth of mezquite, while, in its proper season, large patches of *annual grama grass* relieves the desert of its barren aspect, and transfers the mind to scenes of neatly trimmed pleasure grounds set off with verdant shrubbery.

The next stretch mounts again to the pebbly strewn table-land of the desert, from which you descend further by the steep sandy bluff which bounds the bottom land of the Colorado river.

STREAMS AND WATER-COURSES.

A consideration of the character of the various streams and water-courses in this region belongs properly to the view of its external features, and derives especial interest from the intimate relations they sustain to climate and agricultural resources. On the western slope the various streams, each draining a very limited area, are remarkable more for their number than their magnitude. Having their main sources near the mountain summit, they pursue their tortuous course towards the sea, following all the irregularities interspersed by the separate mountain ranges and their projecting spurs. By these devious courses the descent is finally accomplished without occasioning falls or cascades, which are so commonly associated with mountain streams elsewhere.

Their volume being necessarily dependent on the supply from local rains, they generally attain their greatest bulk towards the close of the rainy season, when the melting snows at their sources combine with frequent showers below to swell their volume. As the dry season advances they gradually contract their dimensions, till in the month of July most of the streams near their mouth become absorbed in their porous sandy beds. The exception to this general fact is seen only in those streams which, having their sources in the higher mountain ridges, receive a sufficiently constant supply to exceed the amount lost by evaporation.

The drying up of the stream beds is a gradual process, necessarily modified by the comparative dryness of the atmosphere, as also by the relative absorbent or retentive character of their beds.

The point at which water ceases to flow is quite variable; its more usual upward limit being marked at or near the passage of the stream from the first rocky ranges into the Tertiary formation. The point, however, as before stated, is by no means a fixed one; thus, during the night it extends further downwards than in the daytime; in cloudy weather, for the same reason, its course is more prolonged than under a clear sky. In the stream beds themselves, however dry, water is generally found a short distance below the surface.

The descent of these streams in the rainy season may be either a gradual process in the progressive saturation of their sandy beds, or the saturation being accomplished by previous showers, the irruption may be sudden. A fine example of this sudden appearance was observed in the San Diego river, in December, 1849; when, after a rainy night, by which its sandy bed was completely saturated, the upper stream suddenly appeared in the form of a foaming body of water, moving onward at the rate of a fast walk, curling round the river bends, absorbing the pools, and soon filling its shallow bed with a brimming swift current.

An instance of the more gradual descent was seen on the following season, December, 1850, when, from the absence of local rain, its downward progress was slow and interrupted.

The facts connected with this supply of running water seems to deserve particular attention in this region, where its presence or absence is synonomous with barrenness or fertility.

The streams of southern California are, in truth, the life-blood of its agriculture, and the means to be adopted to extend this supply can only be efficiently based on a clear understanding of all their separate relations, both as to atmospheric conditions and geological structure. In many of the old mission establishments extensive lines of masonry were constructed, by means of which the streams were tapped a short distance above their place of sinking, and a vigorous irrigating supply conveyed to the lower portions of the valley, thus rendering productive lands otherwise useless for all the common purposes of cultivation.

It is therefore in the true character of these streams—with reference to their sources, their beds, the elevation and geological structure of their banks and bottoms—that we are to look for the fairest general idea of the agricultural capacities of this region.

But it must further be remarked that it is not to these mountain sources alone that we must look for the needful supply of water; occasional springs in the lowest portions of valleys frequently furnish a constant flow sufficient to meet the demands of cultivation over a limited area.

Thus, the extensive mission of San Luis Rey, proverbial for its vertility, depended almost entirely upon such sources of supply. Similar examples in other parts, though rare, may furnish useful indication, in directing the location of artificial means of supply, by the construction of Artesian wells.

Referring to the character of the streams on the eastern mountain slope, we have before noticed their abruptness, also the rapid diminution of volume which they undergo in their steep descent. The excessive dryness of the atmosphere, and the more absorbent character of the strata through which they pass, serves to exaggerate all their peculiarities, as compared with the opposite slope. The streams, equally as vigorous at their sources as those of the other slope, are quickly absorbed in their course, and none at any time acquire sufficient volume to be entitled to the name of river affluents. Thus, though the existence of wide and deeply cut stream beds show the occasional agency of powerful streams, derived from the rapidly embodied force of copious rains, yet their rare occurrence and short continuance only serve, in the main, to give an exaggerated feature of barrenness and desolation to a region where, during the greater part of the year, scanty supplies of water are only attainable from stinted and unwholesome springs.

The point at which water ceases to flow is extremely variable, and exhibits a singular intermittent character: thus, in the morning you may cross over quite a large brook, and at the same place, by noon, find it entirely dried up, to show itself again when the diminished evaporation, at night, allows the ground, instead of the atmosphere, to receive its aqueous tribute. Often you meet with streams, near the lower mountain slope, present at one point of their course and absent at another, thus constantly varying, according to the relative absorbent or retentive character of their beds.

On the desert plains, the stream courses are marked by wide beds, with more or less abrupt banks, cutting through strata of sand, marl, or coarse gravel. Near the mountain base they exhibit steeply inclined plains, strewn with a variety of rounded and angular pebbles.

In the re-entering angles, formed by the irregular projection of mountain spurs, these plains often attain an elevation of nearly one-half the mountain height, and are taken advantage of in the selection of passes.

But the point of all others which has attracted most attention, in reference to the distribution of water on this desert plain, is to be noted in that singular feature, to which the name of "New River" has been applied by the Californian emigrants.

The idea naturally conveyed by this name is that of a running stream, arising in the desert and flowing towards the Colorado river, but its true character is quite the reverse; the current itself, which is by no means constant and at all times irregular, is in the opposite direction, or from the Colorado, while its bed, instead of exhibiting the features of a regularly washed stream bank, shows only a chain of lagoons or marshes irregularly connected, and often spreading over extensive tracts, or at other times contracted within narrow beds. Its novelty, moreover, is sufficiently disproved by the presence of heavy mezquite growth, and other plants and shrubbery usually associated with the presence of water in this region. Indeed, all the singular features in the case are now sufficiently accounted for, in the ascertained fact (first suggested by Major Emory from barometric observations) of the existence of a natural depression, at this point, below the level of the Colorado river at high water. The connexion between the overflow of the one and the appearance of the other has been frequently observed, though the exact course of this connexion has not yet been traced out. Still, all the facts in the case derive their full explanation by referring it to this peculiarity of the Colorado river, which, seeking an outlet for its swollen waters, spreads them in fertilizing deposits to such a great distance from its usual bed.

LAKES AND LAGOONS.

Mountain lakes are of very rare occurrence in any part of the region under examination. The only body of water that I am acquainted with really deserving the name of a lake, is found on the western slope of the mountains, near the parallel of 33° 30′ north latitude, and some twenty-five miles distant from the ocean. It is about five miles long, by from two to four in breadth. It has no outlet, and its waters are consequently brackish. It is also apparently shallow, and exhibits along its banks marks of recent and continuous recession, plainly indicating a gradual exsiccating process. What adds to the interest of this latter fact, is the explanation it seems to offer of the original condition of some of the more fertile basin valleys, which exhibit all the characters of a lacustrine origin, to which they now owe, in a great measure, their fertility. A fine example of this may be noticed in the rich and extensive valley known as the San Bernardino. It is seen encircled by high mountains on all sides, and seems to have derived its subsequent drainage by the Santa Anna river, which is now observed passing through an elevated range of tertiary mountains towards the ocean.

On the desert plain of the eastern side of the mountains, report speaks of one or more extensive salt lakes, but no opportunity was afforded for a personal examination of their true character or extent. The fresh water lakes and lagoons belong to the "New River" formation, which has been sufficiently noticed above.

II.—GEOLOGY AND MINERAL PRODUCTIONS.

Directing the attention more especially to the geological structure of this region, we have to consider the same mountain range, in its line of greatest elevation, constituting a central axis from which we may trace on each side the diversities that characterize its extended flanks.

By reference to the accompanying geological map and sections, *three* main facts will particularly claim our attention, and serve at the same time as the most natural division by which to unfold the entire subject.

1st. The great preponderance of crystalline metamorphic granite pertaining to the older paleozoic series of rocks.

2d. The entire absence of any member of the lower paleozoic, or secondary rocks, in their regular stratified character.

3d. The existence of extensive Tertiary deposits, forming a more or less extended flank, on each side of the mountain range.

1st. In reference to the preponderating granite formation, as exhibited in the central axis, and main development of the mountain range, we shall notice a considerable diversity of form and structure, but all evidently pertaining to the same general formation of metamorphic rocks in their different exposures. Illustrative specimens are characterized by Professor Hall in the accompanying list, to which reference may be had for special characters.

The central axis is represented by a somewhat variable mottled granite, composed of various proportions of *quartz*, *feldspar*, *mica*, and *hornblende*, frequently containing imbedded crystals of *tourmaline*. The exposed mass varies greatly in the degree of aggregation of its component materials, assuming in some places a close sienitic texture, while in others a larger proportion of feldspar renders it more readily decomposable by disintegrating causes—its exposed face easily crumbling into a coarse, granitic sand.

At other points the preponderance of mica, confusedly mixed in large scales, serves to give a very irregular form to the external rock exposures.

Belonging also to the same series, we find, particularly on the eastern side of the range, mica and talcose slates associated with quartz veins.

The irregular rocky range immediately adjoining the coast, and also probably composing the numerous rocky islands extending at variable distances seaward along the same line from northwest to southeast, present a distinct form of eruptive rock, described by Professor Hall as "*greenstone, with soft chloritic spots, or blotches*," and "*porphyry*, or *porphyritic greenstone*." This character of rock forms the first extensive range of mountains east of San Diego Bay, and attains an elevation in some of the higher peaks of 2,500 feet above the sea.

Further to the north, in the vicinity of San Luis Rey, several isolated peaks exhibit a basaltic structure, weathering into peaked domes, with abrupt columnar faces. Professor Hall considers all the rocks of this series as of quite recent origin, compared with the central granite series above mentioned. As sustaining this view, we observe further north, in continuation of this range, near Santa Barbara, evidences of disturbed Tertiary rocks associated with similar or more recent igneous exposures.

The isolated mountain peaks and ranges adjoining the Colorado River exhibit a sienitic texture, which, by exposure to the dry atmosphere, acquires a deep brown, polished face, giving a peculiar and forbidding aspect to the bare mountain scenery

These sienitic rocks are frequently associated with gneiss, exhibiting a very distinct stratified character, occupying a position external to the adjacent igneous rocks.

The immediate junction of the Gila and Colorado Rivers is marked by a singular geological formation. It is composed of an irregular series of rounded knolls, attaining a height of thirty to eighty feet above the river level.

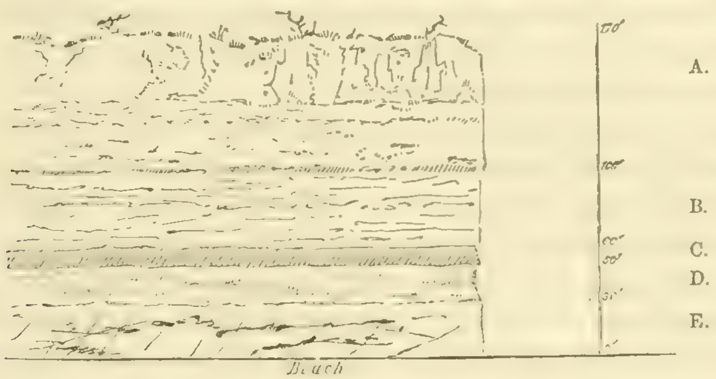
The summit and sides of these knolls are strewn over with the erratic fragments which pertain to the continuous desert formation, and which conceal the central nucleus, except in the deep cleft made by the passage of the Colorado just below its junction with the Gila. At this point we see the central nucleus forming an irregular breccia, composed of variously sized blocks, frequently massive. The rock is a form of greenstone, streaked with epidote. The cementing material is apparently derived from the natural decomposition of the contained rock. On the western side, near the level of low water, there is an underneath exposure of a dark-colored mass, composed of epidote, with talc—the latter being occasionally granular. This material is seen shooting upward into the superincumbent breccia in the form of veins, and would seem to hold some close relation with the disturbing cause below.

The external features of this singular formation we have endeavored to represent in sectional sketches.—(See part 1, pages 128, 129.)

The Tertiary formation.—The Tertiary formation which flanks the mountain range on the west extends to the Pacific coast, forming a belt of variable extent and thickness, and composed of various stratified deposits.

The strata adjoining the sea occasionally presents abrupt ocean bluffs, washed by the waves at high tide; through the same formation the various streams cut their way, forming deeply trenched valleys. The strata thus exposed in the sides of valleys exhibit a slight dip toward the sea, and are seen to be composed of alternate beds of coarse sand, clay, or marl, with occasional beds of interstratified pebbles, all smoothly rounded, and variable in size.

SECTION OF LIGNITE BLUFF NEAR SAN DIEGO.



A. Coarse, feruginous sand, with occasional interstratified pebbles, weathering very irregularly into fantastic shapes, forming miniature peaks and ridges.

B. Coarse, white sand, in even, horizontal strata.

C. Drab-colored sandstone.

D. Fine-grained sand, varying in color from buff to light-gray, containing thin seams of sulphuret of iron.

E. Tough clay, containing an irregular seam of lignite, with smaller portions of mineralized bitumen.

In the vicinity of San Diego, and plainly exposed in the steep bluffs which bound the lower part of the river valley at this place, is observed a distinct fossiliferous layer, having a thickness of about thirty feet. Its lower members, resting on micaceous sand or clay, are not more than twenty feet above the present sea level.

The contained fossils are made up mainly of silicified casts of marine shells, imbedded in a calcareous medium of more or less close texture. The individual forms of fossil species are quite numerous, though the number of distinct species is not great; the most abundant and widely spread is a species of *Turritella*.—(See Plate No. XIX, fig. 8.)

This formation is distinctly traceable at various points up the coast, and in the neighborhood of Santa Barbara is seen to form mountain masses. Wherever noticed, it is overlaid by various sandy layers, forming an upper capping of very variable thickness.

The irregular layer of interstratified pebbles, so frequently seen in hill-sides, seems hardly capable of being referred to any distinct place in the general Tertiary series. Their most abundant occurrence, however, near the mouths of valleys opening on the sea, sufficiently indicate that they are derived from the combined agency of river transportation and tide-washing—having attained their present position by subsequent land elevations.

The junction of this Tertiary formation with the adjoining granite or igneous rocks is seen in a general thinning out of the former, which, at last, barely mantling the protruding rocks, is blended with the result of present decomposing agencies.

Natural terraces and table summits.—Another interesting geological feature, observable in the post Tertiary strata adjoining the coast, is the existence of natural terraces and table summits, of various elevations, and their evident connexion with ancient sea levels—thus indicating successive periods of land elevations.

A series of at least three of these terraces is distinctly noticeable near the initial point of boundary on the Pacific.

The highest of these is exhibited in that striking landmark appropriately named "Table Mountain." Visible, far out at sea, and attaining an elevation of not less than one thousand feet above the present sea level, it presents a distinct outline of abrupt slopes terminated by a regular flat table summit. As it now stands in its isolated character, and not far from the sea beach, it appears to be altogether unique, though, doubtless, more extended and accurate observation of height and situation would show its connexion with some of the higher terraced elevations adjoining the interior mountain slopes.

The next step in the descending series is represented in the average level of the post Tertiary bluffs and hills near the coast, say at a present elevation of two hundred to four hundred feet above the sea. The irregular character of the deposit, at various points, and the evidence of long-continued denuding influences, have necessarily obscured the general level; or, as we may suppose, the land elevation at this period was itself irregular or alternating with periods of depression. It may further be remarked, as substantiating this latter view, that the deposits here exhibited are those most abundantly characterized by the presence of transported rounded pebbles, irregularly distributed, as we have seen, along the course of valleys of denudation.

The third well marked terrace formation in the descending, or more recent series, occurs in close proximity to the present sea beach, and is characterized by a more alluvial deposit, and also the first appearance of recent marine shells, strewn irregularly over its surface in comminuted fragments. A fine example of this formation is met with where the initial point of boundary on the Pacific is marked by the first monument. Attaining an elevation of forty to fifty feet above present tide water, it presents a steep slope seaward, and extends in quite a regular terrace to the adjoining broken hills, before noticed, as constituting the middle terrace formation.

This last step in the series presents in its organic remains, and more alluvial character, an approach to the present alluvial tracts of this region.

Further north, where, from the western bend of the coast the Tertiary belt acquires its broadest dimensions, we have apparently the formation last considered represented in those extensive plains which, extending inland from the sea often several leagues, give character to that section of country by increasing its agricultural capacity.

The commencement of these plains on the south may be seen, by reference to the map, to correspond with the greater development of the Tertiary formation, both in extent and thickness.

Thus to the N.E. of San Juan Capistrano the Tertiary deposits form an elevated mountain range, attaining a height of two thousand feet or more above the sea. Here, also, are exhibited the first signs of internal disturbance in abrupt and variable inclinations of the Tertiary strata.

As the necessary result of all these conditions we have a more abundant supply of material, under the natural denuding influences, for the formation of the lower terraces, or the plains, under consideration.

Some of these plains, encircled by higher Tertiary hills, represent in outline beds of extensive sea bays, of a previous era, now, by the elevating agencies at work, converted into their more attractive land features. A fine example of this latter fact may be noticed on the accompanying map as the "Santa Anna Plain."

Desert formation.—The corresponding Tertiary formation on the eastern side of the mountains must now claim our attention. And first, it will be remarked, in contrast with what we have noticed on the opposite Pacific slope, that the line of junction between the crystaline rock and the Tertiary belt is more distinctly marked.

The character is well exhibited where the stream courses from the mountains enter the Desert plains. They are there seen cutting their way through the Tertiary strata and presenting deep vertical sections of their stratified deposits, consisting of marls, sands, and clays, with a very constant accompaniment of stratified pebbles, the latter of greater or lesser thickness, and forming the most usual upper capping, which constitutes the table summit of the Desert plateau.

It is in the marl and clay deposits that gypsum makes its appearance, being frequently washed out along the edges of the steep bluffs in the form of shining flakes of selenite. Here, also, occur the first marine fossils found to characterize the formation, including species of ostrea.

This marl formation, thinning out to the eastward, gives place to coarse sandy layers of great thickness; thence forming the exclusive substratum of the desert, and extending to the table bluffs, which bound the alluvial bottom of the Colorado river. In this last situation it exhibits a perpendicular wall 60 feet or more in height, overlaid by pebbly deposits, having an average thickness of 20 feet, more or less. These pebble deposits are in this situation frequently cemented by a calcareous medium more or less compact, and occasionally forming a close cretaceous conglomerate.

It is in the geological features thus sketched that we can best indicate the true desert character of this region, covering a vast extent of country, and forming the plateau through which all the rivers of this region take their course. Its deep porous layers rapidly absorbing the waters of occasional heavy showers by which it is visited in the latter summer months, it spreads forth at other times an arid waste often under a burning sun. The wonder is that vegetation in any of its forms can procure the elements for a stinted growth.

The further relation of these strata to the supply of water for the use of travellers is of great importance, and may be briefly alluded to here. It was formerly supposed that no natural reservoirs of fresh water sufficient for the supply of men and animals existed over the entire distance of 80 miles, from the mountain base to the Colorado river. The subsequent discovery of extensive depressed areas, as that constituting "New River," retentive both of rain water and river overflows, has materially shortened these "dry stretches," as they are termed, especially in certain seasons. Due to the same general cause, depressed areas, that have no connexion with flowing water, are the salt lakes of greater or less extent; the degree of saline impregnation necessarily varying according to the amount of aqueous supplies from local rains. The water, however, is rarely, if ever, suitable for drinking purposes.

Even on the higher upland plateaus water is occasionally found in the beds of shallow streams, where the product of recent rains is retained by a clay substratum, the upper sandy layers serving to check the evaporation; but such uncertain sources cannot, of course, be safely depended on during the greater part of the year.

The practical question arises, whether permanent water can be obtained by piercing the coarse sandy layers to a sufficient depth to reach a still lower impervious stratum? As bearing on this question we may cite the irregular character of the argillaceous beds, as seen in various exposures of the lower strata. This irregularity of strata indicates the great probability of finding lower basins of water of considerable extent and capacity connected with sources of supply sufficiently elevated to flow over the surface at the point of excavation.

Still another important question would come up, whether the water reached by permeating through such a depth of saline soil would not be so much impregnated with saline matters as to be unfit for use? But these are questions to be determined by direct experiment, and not by theory.

The "New River" formation, in a geological point of view, must, as we have before remarked, be regarded only as a natural depression in the tertiary series, having a direct connexion with the flowing water of the Colorado river. Its original lacustrine character is sufficiently seen and limited by the presence of fossil fresh water shells, including species identical with those now found living in lagoons adjoining the Colorado. Among these we notice *Planorbis, Physa, Anandorita;* and besides these a small univalve near *Ressoa*, quite abundantly scattered, and often drifting in small heaps over the alluvial sandy tracts which adjoin the lower depressions.

The further relation of these facts to vegetation and agricultural capacity will be alluded to elsewhere.

MINERAL PRODUCTIONS OF SOUTHERN CALIFORNIA.

The inferences to be drawn from the above geological sketch, as regards the actual or prospective mineral products of this region, may here be properly summed up, following out the same general order as before laid down.

1st. The preponderance of the crystalline granite rocks, constituting, as we have seen, the great body of this mountain range, is unfavorable to the existence of extensive or valuable mineral products. Neither does this view seem at present likely to prove erroneous by the recent impulse given to mineral discoveries on this coast.

Many persons, arguing solely from the general similarity of features between certain sections in this region and the gold district to the north, have supposed that an equally diligent search here would yield a like reward to the explorer.

Nothing, however, has yet been brought to light to substantiate this view. The washing of the different stream beds only shows the existence of iron in the form of black sand, and no traces, or very indifferent ones, of the precious metals. This absence of metals we should naturally expect where the crystaline rocks prevail. It is on the eastern slope of the mountains, where talcose slate makes its appearance, with accompanying quartz veins, that we have most reason to expect a correspondence with the gold district of the north. Still no discoveries have as yet, pointed to any valuable result; the quartz veins examined exhibit a very uniform thickness of about 12 inches, and maintain a direction nearly north and south, without showing any disposition to form branches; all of which circumstances must be considered as unfavorable to mineral productions.

It must be left to future exploration to determine the true value to be given to the mineral indications of this district.

The often reported rumors of rich copper deposits in the vicinity of San Diego I have not been able to trace satisfactorily to but one certain source. This locality occurs at some distance south of the boundary line, near the Rancho Guadalupe. The spot itself I have never visited; but authentic specimens shown me exhibit a moderately rich copper ore, composed mainly of *green malachite.*

Such a class of minerals we may reasonably expect to find in connexion with the extensive range of greenstone porphyry adjoining the coast.

There is no satisfactory evidence of the existence of silver ore, or of quick-silver, in the district under examination.

2. The entire absence in this region of any of the forms of stratified rocks comprised in the older paleozoic or secondary period, serves to limit still further the prospective mineral wealth of this district. It excludes at once the idea, which has frequently been in vogue, of the existence of *coal* belonging to the carboniferous period. All the rumored reports of its discovery which I have been able to trace are referrible to certain forms of tourmaline, or more commonly to the existence of lignite or *mineral asphaltum*, so generally associated with the tertiary strata.

3. The mineral products pertaining to the tertiary formation worthy of special notice are but few. On the Pacific coast we have to include the various forms of mineral bitumen, a form of *Tertiary chalk*, together with various other *alkaline earths.*

The mineral bitumen is quite extensively scattered over a large portion of the Tertiary district. It occurs in most abundance where this formation acquires its broadest and thickest dimensions, and is connected more or less with igneous disturbance. In the neighborhood of Los Angeles it occurs in the form of what are popularly termed "pitch springs." In such localities, it is observed issuing in the form of a tarry liquid, becoming hard and of a deeper color by exposure to the air. In this latter form it resembles closely the pitch of commerce, and is applicable to similar uses. In the vicinity of San Diego it is found in the form of irregular patches, spattered over the sand rock, washed by high tide. It is also frequently met with in an erratic form, being silted up by the waves at various points along the ocean beach.

The more abundant product of the bitumen springs, in the vicinity of Los Angeles, is principally in use for the sheathing of roofs, as a protection from rain. In the rough state in which it is employed, however, it has little to recommend it on the score of neatness, presenting under a hot sun a constant dripping from the eaves, disagreeable to the smell, and disastrous in its effects on broadcloth and beaver. At the same time, becoming thin, it requires frequent re-application, and in the cold rainy season is liable to crack, giving rise to sudden leaks. An improvement in these respects might doubtlessly be made, by forming a mixture with some other material, which may serve to add to its solidity without impairing its useful retentive properties. The material might also be used in many places in the construction of aqueous reservoirs, for retaining the product of rains during the wet season. These being located at sufficient height to serve the purposes of irrigation, might thus be made the means of redeeming valuable tracts of land from sterility.

Still further, as an ingredient in the manufacture of sun-dried brick, it promises to come into extensive use, furnishing, at the same time, an almost imperishable article, and admitting of extended useful application in the construction of buildings and fences, with a great saving of bulk of material as compared with the old fashioned "adobe."

In collecting this mineral bitumen for the uses above enumerated, pits of greater or less depth are sunk in the vicinity of the bitumen springs, to which the issue is conducted. This becoming hardened by exposure to the atmosphere, acquires sufficient solidity in cold weather to render it fit for transportation.

Connected, probably, with the same bituminous formation, we find frequently exposed in the sides of ocean bluffs irregular seams of lignite associated with the sands and clays of the Tertiary deposites.

The purer forms of this mineral, at times, closely resemble in external character the bitumens above mentioned, though having a more distinct mineralized structure. It is usually associated with clayey shales more or less bituminous, and frequently marked with obscure vegetable impressions. Fossil remains of lizard's teeth are also, according to the examination of Dr. J. L. Le Conte, found associated with this formation. The lignite never shows itself in any abundance, and neither the article itself or the character of the strata would warrant us in regarding it of any economical importance.

It is to this source that most of the reports of the existence of coal in the vicinity of San Diego have been referred ; a brief statement of the above facts is sufficient to show their unfounded character.

The general appearance of this lignite formation, in reference to the commonly associated strata and their comparative thickness, is represented in the accompanying sectional sketch of *Lignite bluff*, as seen at the mouth of Solidad valley, above San Diego.—(See section, fig. 162.)

A third mineral product pertaining to the Tertiary formation, on the coast, is "a highly aggregated calcareous deposit, resembling chalk ;" this article is found not generally distributed, but in irregular beds, sometimes of considerable thickness. In the absence of all other limestone materials, it is used for conversion into a weak form of quick-lime ; and it is also from some other associated alkaline properties employed in the making of soap.

In the tertiary formation on the eastern side of the main mountain range, the only mineral productions worthy of note are gypsum and common salt. The former is quite abundantly exposed in the marl strata, near the mountain base, where it may probably be found to form extensive beds. In its present inaccessible position it gives little prospect of being sought or applied to any useful purpose.

Common salt, as before stated, is found along the edges of salt lakes on the Desert. In these situations it is said to be procured with ease by superficial digging, and of very pure quality.

For more detailed information in reference to the mineralogical character of the prevaling rocks and earthy deposits, reference may be had to the list of geological specimens, prepared by Professor Hall, of Albany, New York, which will be found in his report.

The geographical boundaries of the various formations, with their relative developments, are indicated in the accompanying map and sections.

NOTE BY W. H. E.

Assistant Arthur Schott passed over the tract of country described in Chapter V. His geological view of it is so similar that I do not consider it necessary to publish it; but I give an extract from his report, which contains some interesting facts in reference to the changes which have taken place in the Great Desert within the historical period, and some general views, which I think are sound, and are applicable not only to the Desert where it is crossed by the Mexican boundary line, but that vast region of desert country which lies to the north of the line, and which spreads out and probably attains its greatest breadth in the region of the Salt Lake.

Whatever may be the opinions of persons interested in the more northern lines of travel and projected railway routes to the Pacific, we cannot shut our eyes to the existence of this Desert on any line of travel south of the South Pass, in north latitude 42°. I am also of the opinion that this Desert, within the limits of the United States, is narrower and more easily passed over by a railway immediately north of the Mexican boundary than on any parallel to the north of it. An attentive perusal of the report of Governor Stevens will show that even north of the South Pass vast tracts of arid and desert regions were encountered in the same longitudinal zone, which, added to the rigors of the climate, form an almost insurmountable barrier to the project of opening through those regions any great highway of travel, either by railway or wagon road, between the Atlantic and Pacific States.

The full power of the government has been directed towards establishing posts and opening these northern lines of travel; yet we have, within the last few months, seen Fort Laramie, Fort Pierre, and, I believe, even Fort Kearny abandoned by the government, owing to the absolute sterility of the soil, and the impossibility of inducing settlements, or raising even vegetables necessary for the use of the troops.

The records of the Quartermaster General's office show the long continued efforts which the government have made to establish these posts as *nuclei* for settlers, and the utter failure to induce settlement, and make the surrounding country at all conducive to the support of the troops. The idea of carving out States from that portion of the American continent between parallels 35° and 47° and the 100th meridian of longitude and the crest of the Sierra Madre is a chimera. The example of the Mormons is often cited to prove the capacity of the country to sustain population. They occupy an oasis in this great Desert, and their power to sustain even the population they have is by no means established beyond a doubt. On two occasions the grasshoppers were very nearly eating them out and producing a famine; and I am very sure, if it were not for their peculiar institutions, which cannot bear the light of civilization, they could not be induced to remain in their isolated and desert home.

We learn from the report of Captain Beckwith, United States army, how very circumscribed is the area of land which is now susceptible of cultivation in the Desert, and the fact that families sometimes go a great distance from the settlements for the advantage of obtaining a few acres of ground susceptible of cultivation. (See page 65, vol. I, Pacific Railroad Report.) When the truth comes to be admitted, I think it will be found that the upper valley of the Rio Bravo, embracing New Mexico and a small portion of western Texas, is the only tract of land, within the limits mentioned in the preceding paragraph, where a body of land is to be found susceptible of sustaining any considerable population. And yet we see, since our occupation of that Territory, in 1846, the population has increased but little, if at all.

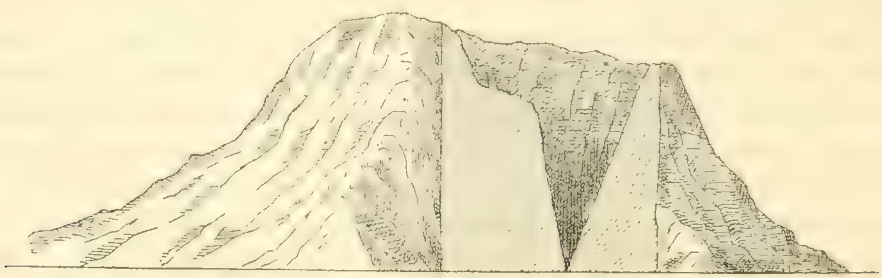
[EXTRACT FROM REPORT OF ASSISTANT ARTHUR SCHOTT.]

TERTIARY SHORE OF THE DESERT.

Vallecito, another small Indian settlement in a valley with a number of brackish springs' and abounding in saline soil, is situated on the upper edge of the Desert shore. From Vallecito the road continues along the dry bed of a mountain torrent, deeply filled in with shifting sand. This sand stream seems to form one of the heads of Carrizo Creek, and winds through dreary flats, flanked on both sides by the naked, desolate slopes of the primary and metamorphic mountains. The latter finally cease, and Tertiary ridges, supported by dark masses of eruptive rocks, take their place. These form the real edge of the Desert ocean, which, no doubt, was once the bottom of a wide salt-water basin. The washing of tidal oscillations upon this bold shore caused, probably, the dune-like deposition of the Tertiary hills along the foot of the western Cordilleras. To confirm this supposition of their origin, an isolated group of seabeach-loving palms appear to the left of the road, near Carrizo Creek, marking, at the same time, a spot with permanent water. A brief but graphic description of those Tertiary ridges and hillocks has been brought before the public in Major Emory's report of 1848.—(See page 103.) A sketch of these hills is herewith given.

VOLCANIC VENTS.

Among the Tertiary ridges and hillocks, one may be recognized at once by its singular shape, appearing to be the vent of some volcanic activity now silenced. Major Emory, according to our knowledge, set forth, prior to any other writer, the supposition of the true nature of these hills. After close examination we are able to corroborate the correctness of that supposition. Another not less convincing proof of its neptuno-volcanic origin may be sought in its geographical position, which is upon that long volcanic seam, running north and south, and lining the eastern base of the Peninsular Cordilleras, parts of which are still in activity.



VERTICAL SECTION OF AN EXTINCT CRATER IN THE TERTIARY FORMATION, BORDERING THE EAST SLOPE OF THE CALIFORNIAN CORDILLERAS.

VIEW UPON THE EASTERN SLOPE OF THE CALIFORNIAN CORDILLERAS FROM NEAR CARRIZO CREEK.

SOLFATARAS.

Some volcanic mud springs or solfataras, to the north, in the Colorado Desert, have been visited by Dr. J. Le Conte, of Philadelphia, in company with Major Heintzelman, U. S. A., then commanding officer at Fort Yuma. The former gives an interesting account of his visit there in Silliman's Journal, vol. xix, second series, No. 55, January, 1855. The existence of these springs, however, was not altogether a new discovery of this party, but was well known before to the natives of the country, who resorted to this locality for their annual supply of salt.

The other springs, southeast from Carrizo Creek, and not more than twenty miles from the lower Colorado, were visited also, in 1853, by the same officer, accompanied by a small party. The time this officer had chosen for his trip was about three months after a severe shock of an earthquake, which had terrified the inhabitants of those regions on the 29th November, 1852.

We are indebted to the liberal kindness of Major J. H. Thomas, the successor of Major Heintzelman, in command of Fort Yuma, for a glance at the manuscripts of the latter. The description of the springs and what was known is, in substance, as follows: "There exists, about forty-five miles below Fort Yuma, in the Desert between the western Cordilleras and the Colorado, a pond, considered as an old orifice, which had been closed for several years." "The first shock of an earthquake, in 1852, caused there a mighty explosion. The steam rose a beautiful snowy jet more than 1,000 high into the air, where it spread high above the mountains, gradually disappearing as a white cloud.

"This phenomenon repeated itself several times in a diminishing scale. Three months later I visited the place; jets took place at irregular intervals, from fifteen to twenty minutes. The effect was beautiful, as they rose mingled with the black mud of the pond. The temperature of the water in the principal pond was 118° Fahr., in the smaller one 135° Fahr., and in one of the mud holes, from which gases escaped, 170° Fahr. The air which escaped was full of sulphurated hydrogen, and in the crevices crystals of yellow sulphur were found. The ground near about was covered with a white efflorescence, tinged with red and yellow. On the edge of a small pond crystals of sal ammonia, 1 to 5 inches long, were collected."

CLAVIJERO'S ACCOUNTS OF LOWER CALIFORNIA.

Other important data bearing upon the geology of Lower California have been brought before the public a long time ago by Clavijero, one of the missionaries in the southern part of the peninsula. He mentions, in his Historia de la Antigua ó baja California, (see Book I, Chapter II,) "two lagoons near the mouth of the Colorado; the red water of the former gave rise to the river's name." The water is described as being very caustic, and so bad that it causes instant swelling and ulcers, accompanied by a burning pain on any part of the body that is brought in contact with it. The effect is said to last for several days. The cause of these bad qualities is likely to be a certain bituminous mineral issuing from the bottom of those lagoons, where some navigators noticed it first in weighing their anchors.

Besides these lagoons quite a number of interesting facts are mentioned by the same author.—(See Book I, Chapter III, of his work.) Relating to the volcanic character of the shore skirting the base of the Peninsular Cordilleras, the volcano of Mulegé, near 27°, is mentioned. It was discovered in 1746, by the missionaries; but the Spaniards living there made no mention of any eruption or earthquake caused by it. Native sulphur and pummice abound on the slopes and in the vicinity of this mount. A volcanic axis seems to traverse the peninsula from shore to shore, that is, from the mouth of Mulegé River to the Ballena's Bay, where, besides native sulphur, much vitriol occurs.

At a place called Kadakaamang, near the Mission of San Ignacio, in latitude 29°, an argillaceous mount is mentioned near the beach. On its slope, about 200 feet above the level of the Gulf, there is a horizontal stratum of fossil shells two feet thick.

About seven miles distant from this place a great many fossil oysters are found, some of them being of extraordinary size. One of the missionaries collected some measuring 1 foot 5 inches long, 9 inches broad, and 4 inches thick, and weighing 23 Spanish pounds. It is worthy of notice that here, and in other parts of California, from such fossil shells an excellent lime is prepared.

Around the Bay of Mulegé fossil ostrea are recorded to be quite common, especially on a high mountain in the vicinity of the beach. The rocks here are described as exceedingly hard, and well adapted to building purposes. It abounds in fossil shells, which are found imbedded in the innermost strata. It contains also numerous cavities, which seem to have been once occupied by some marine animals now extinct. This certainly proves a submarine formation of the mountain.

Rocks of a similar class occur frequently along the whole coast of the Gulf. Seven or eight miles from Loreto, in a locality surrounded by high mountains, is a ridge which is said to consist entirely of layers of fossil shells; similar localities are known to exist more than twenty miles from the Pacific coast, near the Mission of San Luis, on the north side of the Sebastian Viscaino bay.

Clavijero thus concludes: "Considering these facts in connexion with the various traces of volcanic activity, and the lar number of islands surrounding the Peninsula, we may imagine what revolutions nature has performed upon this ground. It is, moreover, beyond doubt that the sea has subsided (decrecido) in many places along the coast."

The missionaries of Loreto observed there, during less than forty years, that the tide marks of the sea had receded many yards from the coast, and also that such receding was more perceptible on the west coast. The whole space between the beach and the mountains, a distance of about 26 miles, is deeply overlaid with coast sand (arena litoral.) It is, therefore, evident that the Peninsula in its present configuration has more width now than before our historical era. We may also surely suggest the probability of a continued expansion of the land, until that multitude of islands around California shall be connected with each other and be consolidated finally with the main land.

VOLCANISM THROUGH THE GULF BASIN.

North of Carrizo Creek the country between the Gulf Basin and the Pacific exhibits perfect congruity of petrographic features. There is, for instance, the Pass San Gorgoño y Bernardino, formed by two huge mountain masses, with an elevation of from 7,000 to 8,000 feet each. Here diluvial deposits form a natural bridge of about two miles in width through that mighty granite gate. This was once the passage of the tidal currents between the Atlantic and the Pacific.

The protrusion of eruptive masses skirting the base of the California Cordilleras seem to have been checked here by some means; their occurrence is at least less frequent in this neighborhood. A little further north, however, another shoot of igneous and metamorphic rocks abuts against the western granite walls. They are a northwestern continuation of the Sonorian Gulf Sierras, crossing the Colorado Valley in the vicinity of the mouth of the Gila, and joining the California Cordilleras somewhat to the north of the before mentioned mountain pass.

Along the eastern base of the Sierra Nevada we find volcanic activity again fully developed. It not only skirts these walls of primary and metamorphic rocks, but seems to have its theatre over the whole area between the Rocky Mountains and the Sierra Nevada.

According to the accounts of American and other explorers, this vast area abounds in salt lagoons, soda lakes, solfataras, geysers, warm and hot springs of various character, extinct craters, and other traces of wide-spread volcanoism.

Tertiary deposits seem not to be wanting throughout these regions; some of them are proved beyond doubt to belong to the Miocene age. Numerous fossils, verifying such conclusions, have been collected by various persons connected with government expeditions. Among other discoveries, is one of the highest importance; this is, the existence of a fossil shell (Cardita planicosta) on the Pacific slope of the Sierra Nevada. This shell, originally belonging to the Paris basin, is common also on the Atlantic side of this continent, and is now known to occur also on the Pacific. From this we have the proof of a former immediate connexion in these latitudes between the two oceans of our globe.

Without making any further mention of other numerous geological and palæontological facts relating to those regions which have been brought to light since the last decenium, we consider the area from the present head of the Gulf up to the Great Salt Lake basin as one tertiary, if not quaternary sea. There were, besides the present Gulf, other inlets from the Pacific to this interior sea; some of them we know already, and others, no doubt, will be discovered a short time hence.

However wide this inland sea may have extended, we find on its western shore primary and metamorphic rocks lined by tertiary strata, and on the east shore metamorphic and volcanic rocks prevail.

The bottom of this present waste, thickly overlaid with diluvial deposits, seems to have been thrown out of its level by upheaving forces from below. We may call them pluto-volcanic, employing a term to designate the immediate ejective forces and the upheaving motions of a general character.

In the regions before us we have innnmerable traces of ejected masses, in the shape of igneous dykes and sierras of similar petrographic character, but varying in size. We find, in fact, the former horizotalism of the whole Gulf basin along the Rio Grande and its tributaries, everywhere traversed, intercepted and broken up by metamorphic and igneous mountain ranges. It seems that the observer, in no other locality, stands in closer presence of these very pluto-volcanic upheaving forces, than on the western edge of this ancient inland sea. Whoever passes over this ground, particularly the desolate scenery about Carrizo Creek, if his mind should be the least open to impressions of this kind, must be struck with awe! He will find himself in a locality where nature gives, in a few bold words, a whole sentence of her cosmogonic history.

Here we everywhere find distinct marks of metamorphism, the result of a closely allied cyclopean and neptunic activity.

Changes in the physiography of the country.—One fact closely connected with the physiography of these desert regions is worthy of notice. The regions around New River and other beds of drainage, are inhabited by Indians, who raise on those alluvials, pumpkins, melons, and reap the seed of certain grasses and seeds, especially of an "Amaranthus," called by the Mexicans "Quelite," and by the Americans "Careless weed." These plants are dependents of alluvial soil.

At present the New River is often subject to dry up entirely for one or two successive seasons, thus leaving this forlorn people to the most bitter adversity. Whether this was always the case we were not able to find out, but there is some probability such was not, for if it had been so, these Indians or their ancestors would not have settled in this neighborhood.

According to traditions and observations made on the spot, water must have been distributed in former times more abundantly over the desert west of the Colorado, since either changes in the conditions of the climate or alterations in the level of the land, or both, must have taken place, causing a gradual diminution of drainage, and necessarily a subsequent decrease of population.

All accounts which have come to our knowledge agree upon an increased sterility of soil. Several localities are pointed out where in former times plenty of grass and mezquite, besides spacious planting grounds, were found.

Pascual, the present chief of the Yuma Indians, when a child, lived at "Alamo Mocho," where at the time (he is now about 60 years of age) water was running constantly, as it did also at New River. The place of Pascual's childhood was called Hu-ta-pil, because plenty of tunas (the fruit of opuntia) grew there. Of all this, nothing seems to have been left but the name "Alamo Mocho," (stunted cotton-wood,) as one tree of the kind marked this locality long after water had ceased to run here. If such changes really have taken place, and there is hardly room for doubt, we are inclined to ascribe the cause to an alteration of level—hyetographical changes being, perhaps, but the result.

It is not improbable that this portion of the Peninsula participated in a similar rising as Clavijero mentioned in regard to the southern regions of this country.

We have already mentioned the earthquakes to which these regions, together with all California, are subjected. They may be considered as principally instrumental in producing those general changes upon the surface. Here every three or four years heavy vibrations of earthquakes are witnessed. Major Heintzelman thus writes of a severe shock experienced the 29th of November, 1852: "At the time the river was unusually low, and (the Laguna) behind the post uncommonly high. (Behind Camp Yuma there is an old river bed.) Low grounds became full of cracks, many of which spouted out sulphurous water, mud, and sand. Further below, the river bed was changed considerably. The re-opening of a salfatara in the southwest corner of the desert was mentioned as the result of this earthquake."

Similar accounts of the same event were given by another eye-witness. He was at the time on board a small river steamer, about twenty miles below the mouth of the Gila, and on guard, when a heavy shock was felt on board, upon which the general alarm was given, "Boat aground!" Our informant, formerly a sailor in the South Pacific, on the coast of Peru, and also a visitor of the Sandwich Islands, having witnessed there the outbreak of the notorious "Ruaroa," knew instantly what it was, and coolly remarked, touching bottom with a sounding-pole: "Yes! Boat aground in eight feet water!" The waters of the river were thrown in a sort of boiling motion, with a strongly rippled surface. The river banks on one side caved in; and on the other separated in a thousand cracks, from which dust, sand, mud, and water was jetting. In front of the steamer, at the time, there was a ferry-boat, loaded with sheep, just crossing the river. The hands in charge of it not knowing what to think of the phenomenon, in their fright threw away their oars and poles, and held on to the sides of the boat, expecting to go down. The river formed new bends, leaving portions of its old bed so suddenly that thousands of fishes were left lying on the muddy bottom to infect in a few days the air along the river by their putrefaction. The frequency of earthquakes occurring here forms also a point in the mythology and traditional tales of the aborigines, which has been referred to elsewhere.

Mountain rupture.—Eight miles below Fort Yuma another trace of the action of earthquakes is exhibited on the eastern foot of the Sierra Culaya, or Pilot Knob, as it is styled by the Americans. The metamorphic rock forming the knob is a dark syenitic granite, with much hornblende. At its base the Colorado turns abruptly to the south. One of the outrunners of the sierra shows a rupture with an average width of about thirty feet. The edges of this mountain cleft fit each other, so as to leave no doubt that they formed one mass. By means of this gap the post-tertiary banks of the river, 70 feet high, can be seen. (See annexed sketch.) The course of the Colorado, which runs on higher ground than the surrounding desert, and the configuration of the junction of the Gila and Colorado, (elsewhere described,) is, perhaps, another result of a geological disturbance in the general level of country.

Dr. J. Leconte, in his notes on some volcanic springs in California, which have been heretofore referred to, mentions also the anomalous course of the Colorado not taking the lowest level of the desert, but retaining its bed about 130 feet above it. He ascribes the cause to the deposition of its sediment, somewhat like the Mississippi and other rivers in our southern States.

The explanation ascribing the anomalous course of the river to the deposition of its sediment may be correct to some extent, but we deem it not sufficient to account for so great a difference of level.

A glance at the profile of this country will explain the relation between its geological and meteorological condition, which I have before hinted at.

Clouds rising from the ocean, borne by aerial currents towards the mountain slope of western California, ascend easily towards the dividing crest. As soon, however, as they pass that line they meet columnar currents of heated air whirling up from the intensely insulated desert flats; dispersion and dissolution of those aqueous deposits of the atmosphere follow naturally, and hence the almost incessant drought the Colorado basin is subject to.

Rain destined to fall upon these desert regions needs probably some heavier disturbances in the electro-magnetic action of the air, and hence what is called the rainy season in these regions is nothing more than the hottest time of the year, when electro-magnetism comes to its highest pitch of activity.

Equal causes produce similar results, therefore the meteorology of the Colorado basin and Northwestern Sonora are nearly related.

VALLEY OF THE COLORADO DEL OESTE AND EAST SLOPE OF THE SIERRA, CULAYA.

UNITED STATES AND MEXICAN

BOUNDARY SURVEY,

UNDER THE ORDERS OF

LIEUT. COL. W. H. EMORY,

MAJOR FIRST CAVALRY, AND UNITED STATES COMMISSIONER.

GEOLOGY AND PALÆONTOLOGY

OF THE BOUNDARY:

BY

JAMES HALL,

OF ALBANY, NEW YORK.

GEOLOGY AND PALÆONTOLOGY.

Colonel W. H. Emory,

Commissioner for the United States and Mexican Boundary Survey.

Sir: In accordance with your direction, I herewith transmit to you my report relating to the Geology and Palæontology of the Boundary Survey.

The collections of the original survey were placed in my hands, in 1853, by Dr. C. C. Parry, of the Boundary Commission. These consisted of a series of rocks, minerals, and fossils, collected along the line of the survey, and along the route travelled through Texas. The fossils consisted chiefly of Cretaceous and Tertiary species; and some of these had previously been submitted to Mr. Conrad, who described several species in the Proceedings of the Academy of Natural Sciences, of Philadelphia. There were still in the collection a considerable number of undescribed species; and although placed in my hands for final arrangement and disposition, I preferred that Mr. Conrad should complete the work he had begun, and accordingly transferred the new species to him for description. In the meantime, I had the drawings made and arranged as far as practicable previous to May, 1854. At this time an examination of some collections that had remained in Washington brought to light other species, and the number of figures and plates were increased by these additions.

The collections of the Survey of the New Boundary, in 1854 and 1855, have also contributed several new species to those previously described, and these I have likewise submitted to Mr. Conrad,* in order that the descriptions might, as far as practicable, possess a unity of character and design.

The collections have largely contributed to our knowledge of the extent and character of the Cretaceous formation in the southwest. This information, taken in connexion with the results which have been obtained in the west and northwest, enable us to determine with a great degree of accuracy the character and relations of the different members of the Cretaceous period, as developed in the United States.

The collections of Palæozoic fossils contain specimens from the upper carboniferous or coal measure limestone, which is known to become extensively developed in the west and southwest. A single specimen of *Asaphus* (*Isotelus*) indicates the existence of lower silurian strata, and since the specimen is scarcely worn, it cannot have been transported from a distance. It is the first specimen of undoubted lower silurian age that has fallen under my observation in all the collections that have been made in the southwest. I should not, however, omit to remark, that a specimen of coral found in the same locality (though exhibiting no decided marks of trans-

* Except the few species of Echinoderms, which, at the request of Mr. Conrad, I have described in their proper place, one only being a new species.

portation) is apparently identical with specimens found in the immense drift deposits far to the northward, in Nebraska and at other places; and although quite possible that both the trilobite and the coral have been derived from the extreme northern exposures of the older rocks, I am nevertheless prepared to expect that these formations will be found nearly coextensive with the carboniferous limestones.

Although there are among the collections of the Boundary Survey several specimens which appear referable to a position below the carboniferous limestones, and in the later collections some silurian or devonian corals, yet in the absence of other information than that furnished by the specimens, which do not bear evidence of having been freshly broken from the rocks, I do not feel warranted in drawing any general conclusions. This subject is one of the greatest interest for future explorers in that region.

The specimens of igneous and metamorphic rocks from the eastern and central portions of the route travelled are all unlike those so well known in the eastern part of the United States; and it is not until we approach the range of the Cordilleras that we find specimens bearing all the lithological characters and associations of the metamorphic rocks of the Appalachian chain.

We are constrained to believe, not only from the evidences of this collection, but from others previously examined, that the metamorphic rocks of this intermediate region are to a great extent newer than those of Silurian and Devonian age, which we know to be the age of a large part of the metamorphic portions of the Appalachian chain. This conclusion, or we may say suggestion, is deduced from the differences in lithological character, as well as from the fact, already stated, that the upper carboniferous limestone is the most conspicuous unaltered rock of the region, while in some places this rock itself, as well as strata of more recent date, appear to pass into a metamorphic condition.

In regard to this carboniferous limestone, it should also be borne in mind that it is not the carboniferous limestone of the Mississippi valley which attains this force farther west, but a limestone high in the coal series, and which has become thus developed, while we are yet ignorant of the existence of the lower carboniferous limestone in that part of the country.

The collections of the Boundary Survey, when compared with those made in traversing the country along lines farther to the northward, present a great similarity of aspect and lithological character. The cretaceous belt, bordering the metamorphic and igneous region which succeeds in turn, and in the midst of which are large areas of limestone just mentioned, and also some smaller areas of cretaceous rocks, which have now been traced quite to the central part of the great basin to the west of the first mountain chain, and have more recently been determined in California.

We have the means of knowing, therefore, the general geological structure of the country, from near the northern limits of the United States to Mexico.

The first part of my report, constituting the observations upon the specimens collected, and the general results regarding the geographical distribution of the formations along the line of the Boundary Survey, are essentially the same that I transmitted to you in 1854; but which, in consequence of the change in the boundary line making a re-survey necessary, were not published at that time.

I have since reviewed the whole collection, with all the additional information derived from other sources, and comparison of other collections from rocks of the same age, and particularly those of the cretaceous period from western localities and from New Jersey. These results are given in the chapter upon the relative position of the cretaceous fossils of the Boundary Survey with other known cretaceous formations in the United States.

The relations of the carboniferous limestone of the Rocky Mountain range, I have endeavored to make more clear by a few pages upon the carboniferous rocks, and a section of the principal members belonging to that period, as known in the Mississippi valley.

The specimens from the Tertiary formation of the southwest, although indicating a general similarity to the formations of Nebraska, are nevertheless insufficient to give the means of careful comparison and reliable conclusions.

Our knowledge of the geological formations of the west is now so rapidly progressing, and the materials accumulating in such abundance, that whatever may be presented to-day as new and in advance of previous knowledge, will to-morrow be regarded only as a historical record of our progress. The facts here presented, and the conclusions deduced from these and other collections which I have heretofore examined, may serve as a contribution towards a more perfect elucidation of the geology of this great central region, which has been traversed by the Boundary Survey commission.

I have the honor to remain, very respectfully, your obedient servant,

JAMES HALL.

OBSERVATIONS UPON THE CHARACTER AND GEOLOGICAL AGE OF THE SPECIMENS OF ROCKS AND MINERALS SUBMITTED TO MY EXAMINATION FROM THE COLLECTIONS OF THE UNITED STATES AND MEXICAN BOUNDARY SURVEY.

I. *Specimens from the Gulf Coast, Texas, as far as El Paso, including all those from the east side of the Rio Grande.*

1. Calcareous sandstone, branch of the Guadaloupe river below San Antonio. This rock is apparently of Tertiary age, and presents nothing peculiar in its character, except its loose aggregation and numerous dark siliceous specks or grains.

2. Calcareous conglomerate, fifteen feet thick.

These specimens bear the character of the Tertiary sandstones known in Kansas and Nebraska. They are sometimes highly calcareous. The sandstone varies in character from loosely aggregated and incoherent sand to a compact calcareous sandstone or quartz rock, for the grains sometimes appear to have been cemented by fluid silica.

From information obtained in connexion with these specimens, the strata to which they pertain occur in outliers of greater or less extent, the original formation having been subjected to extensive denudation. The similarity in lithological character and association suggests a probable identity in age between these beds and those of the Mauvaises Terres of Nebraska; and that the Tertiary is probably co-extensive with the cretaceous formation from Nebraska to Texas and New Mexico.

3 and 4. Argillaceous, buff-colored limestone, a thickness of fifty feet, ascertained in sinking a well, while the entire thickness of the rock is much greater. This rock is used for buildings in San Antonio. It has the same lithological character as the stratum which elsewhere contains *Inoceramus mytiloides.—I. problematicus.*

5. A yellow granular limestone of similar character, but more compact than the limestone of Timber creek, New Jersey. The specimen contains a species of cardium. The rock from which this specimen was obtained occurs about twenty miles further to the west than Nos. 3 and 4, and is penetrated in reaching a more compact stratum below.

These specimens are from the lower part of the cretaceous formation.

a. *Specimens from the table-land on Devil's river.*

6. Light gray limestone with cretaceous fossils. Painted caves.

7. A more granular limestone than the preceding, resembling No. 5 in character, and containing valves of an *Ostrea.* Painted caves.

8. Compact, reddish brown granular limestone, containing *Nodosaria.* This rock, on its weathered surface, is of the character of the preceding, but more compact and crystalline in its texture.

9. Compact, subcrystalline, yellowish limestone; sometimes of a brownish yellow. Table-land beyond Devil's river.

10. Vesicular trap from isolated hills and ridges rising from the table-land.

11. Compact, light ash-colored limestone, containing cretaceous fossils; among which are *Lima Wacoensis, Trigonia Emoryi, Gryphæa Pitcheri,* and other species. Camanche crossing, Camanche springs.

b. *Specimens from the Limpia range of mountains, between the Pecus river and Rio Grande.*

12. Brown porphyritic trap rock, with crystals of Adularia.

13. Coarsely crystalline igneous rock, (trap-like in some parts,) composed in a great proportion of crystallized feldspar or Adularia, having a châtoyant lustre on the cleavage faces. This rock forms the central part of the mountain range.

14 Compact quartz rock, of a slightly reddish tint, with minute cavities.

15. Compact white opaque quartz, approaching chalcedony in its characters.

These specimens from the Limpia range are of igneous origin, the quartz rock having been derived doubtless from the gelatinous silica produced by volcanic waters. We have no evidence from the facts before us that any part of the range consists of Metamorphic stratified rocks. They are mostly of reddish-brown porphyry and a coarse granitic aggregate, of which Adularia forms a large part. Some specimens of milky quartz appear as if due to depositions from hot springs.

c. *Stratified rocks to the northwest of the Limpia range.*

16. Compact, fine grained limestone, dipping to the southwest.

17. Same as the preceding.

18. Limestone of similar character to the preceding, containing remains of crinoidal columns and shells.

19. Similar limestone with remains of shells; (Brachiopoda, etc.)

20. Limestone like the preceding, of a grayish blue color, containing fragments of *Terebratula*, etc., (probably *Terebratula subtilita.*)

Although these specimens present no well marked fossil species, I am nevertheless quite convinced, from the character of the fragments preserved, that the rock is of the age of the upper carboniferous limestone. The condition and character of the rock with the fragmentary fossils is precisely identical with specimens from the neighborhood of the Great Salt lake and other western localities. They contain remains of small Terebratula in like manner; and the numerous fragments of organic bodies which cover the weathered surfaces indicate sufficiently that the rock is in great measure composed of similar materials. Some of the specimens are quite compact, and others are granular in texture; they are traversed by minute veins, sometimes of calcareous spar, and sometimes of harder material.

21. Siliceous tufa, resembling trap tuff. It consists of an aggregation of finely divided siliceous matter, porous or minutely cellular in structure. It is represented as forming dykes in the limestone. Two specimens from Eagle spring.

22. Specimens similar to the last, but coarsely laminated, and with minute concretions; brecciated, etc. Eagle spring.

23. Light-colored amygdaloid rock. Eagle spring.

24. Porphyritic trap. Eagle spring.

25. Brown porphyry; compact.

26. Brown porphyry; same as the preceding, except that it contains cavities, which are probably due to the weathering out, or solution of crystals from the mass.

27. Chalcedony mixed with Feldspathic lava. This rock has been formed by gelatinous silica penetrating scoria or other loose volcanic materials.

28. Chalcedony. Two specimens, associated with the preceding rocks.

The volcanic products present numerous modified conditions, from the effect produced by silica in solution, or in the gelatinous condition, having penetrated the mass. From this cause, and from the effects of heated water, not only the lithological aspect, but the color of the rock is often greatly modified.

29. A siliceous stratified rock, apparently a highly altered sandstone. From the Rio Grande, seventy miles below El Paso.

30. A porphyritic trap-like rock, perhaps a sedimentary rock altered by volcanic action. Seventy miles below El Paso.

31. Greenstone trap. Seventy miles below El Paso.

32. Volcanic breccia, a gray feldspathic mass with hornblende. Same locality as the last.

33. Volcanic breccia, becoming porphyritic; more compact and crystalline than the preceding.

34. Granitic mass; a volcanic granite, composed of feldspar and hornblende, with little quartz; probably a further modification of the breccia by igneous action. Seventy miles below El Paso.

The range east of the Rio Grande, seventy miles below El Paso, has furnished specimens of reddish and greenish compact porphyry, compact trap, a specimen of granitic structure consisting of feldspar, mica, and some earthy matter, but loosely aggregated, not unlike the products of recent igneous formations; also several specimens of volcanic breccia loosely aggregated, and a single specimen of similar composition very compact in texture. From this locality there is also a specimen of carboniferous limestone, partially crystalline, and one side permeated by innumerable minute pores; but it still preserves evidences of organic remains on its weathered surfaces.

d. *Specimens from the Tertiary Basin of the Rio Grande.*

35. Selenite mixed with marl from a bluff composed of marl, gravel, and beds of selenite. The crystals occur in detached groups, but altogether form large beds.

36. Cretaceous limestone with *Exogyra texana,* and *Serpula.* El Paso.

37. Argillaceous limestone with *Inoceramus,* from the Rio Grande above El Paso.

38. Hornstone with seams, or a brecciated intermixture of limestone with hornstone, forming the summit of a mountain 1,200 feet high. The base of the mountain is composed of the upper carboniferous limestone. Near Frontera.

39. Black hornstone, surrounded by a lighter colored mass of the same. Near Frontera.

40. Feldspathic or granitic volcanic rock, composed mainly of Feldspar and Olivine. Two specimens from near Frontera.

41. Compact feldspar with a little glassy quartz: forming knobs and dykes running through the limestone strata; sometimes overlying and sometimes underlaying the latter rock. It is evidently of volcanic origin.

No. 40 forms isolated knobs less intimately connected with the limestone than No. 41.

The specimen marked "Isolated knobs near Frontera," consists of feldspar and olivine, and is a modern igneous product.

The specimen marked "Granite, north of Frontera," is a similar aggregate, more compact and containing scales of mica.

The mountain northeast of Frontera is partially composed of reddish feldspar with small grains of crystalline quartz ; a kind of porphyritic rock. The position of this rock is remarkable and highly interesting. A sectional sketch of the mountain by Dr. C. C. Parry, represents it as resting on the upturned edges of the strata of carboniferous limestone, which form the base and greater portion of the mountain, and dip at an angle of 45°. The granitic aggregate rests on the sloping sides of the mountain, in the direction of the dip. At a little distance from this point, and apparently resting on the latter rock, occur cretaceous strata, highly inclined, as if the igneous mass had been forced out near the junction of the carboniferous and cretaceous beds. In other instances the igneous beds rest on the cretaceous deposits ; leaving no doubt that the eruption took place subsequent to the cretaceous period.

The specimens from 35 to 41 inclusive, present the characters of the different members of a section across the Tertiary and cretaceous strata, to the upper carboniferous limestone ; with the associated igneous rocks which form separate and isolated masses, or are more or less entangled in the stratified limestone.

e. *Specimens from the Organ Mountain range, fifty miles north of the locality of Nos.* 40 *and* 41. *The elevation of this range is about* 2,000 *feet above the bed of the river.*

The specimens from the Organ Mountains consist of compact feldspathic granite with very little quartz, a few scales of green mica and hornblende, and numerous minute crystals of magnetic oxide of iron. Notwithstanding the compactness of this mass, the character and mode of aggregation are so similar to some of the well-characterized volcanic products that it can scarcely be regarded as an ancient granite. Resting on this rock occurs very compact greenstone porphyry. A specimen from the western base of the mountain is a reddish lava-like porphyry with a finely porous or vesicular structure.

42. Granitic rock, composed of crystalline feldspar with a smaller proportion of quartz and hornblende. The specimen is less lava-like than No. 40, but it has the aspect of a very modern igneous rock. This constitutes the central portion of the mountain range.

43. Porphyritic greenstone, very compact, forming the mass partially surrounding No. 42. This rock occurs in distinct layers dipping at an angle of 82° W.

44. Brown porphyritic trap, overlying the granitic central mass of the mountain.

45. Reddish brown, compact, lava-like rock, containing minute crystals of feldspar; associated with Nos. 42, 43, 44, forming extensive masses.

46. Sulphuret and phosphate of lead, sulphuret of copper, and sulphate of baryta. There are several specimens all presenting the same general character, and obtained from a vein in the mountain range.

47. A coarse porphyry ; a red, coarse, loosely aggregated base. Near the San Antonio road.

48 Volcanic breccia. Near the San Antonio road.

49. Amygdaloidal trap ; a common, grayish base with round vesicles. Tascate.

50. Porphyry.

51. A porphyritic rock with chalcedony.

52. Compact, laminated porphyritic rock.

53. Compact, micaceous, gneissoid sandstone, slightly calcareous; dip S.S.E. 60°.

This sandstone has the aspect of a cretaceous or tertiary sandstone.

54. Laminated, compact, argillo-calcareous rock, which has been subject to igneous action, and partially altered.

The two preceding specimens are from strata overlaid by trappean rock, before noticed; and their altered condition is doubtless due to this action. This fact places the date of these eruptions subsequent to the cretaceous period, and perhaps posterior to the older Tertiary deposits.

55. Encrinital, subcrystalline, light-gray limestone, containing numerous fossil fragments; belongs to the upper carboniferous period; dip to the southeast. Cibolo creek.

56. Argillaceous sandstone with mica, fine-grained and thinly laminated. The age of this sandstone is doubtful, but it may be carboniferous. Cibolo spring.

57. Compact porphyry. Cibolo creek.

58. Limestone of the upper carboniferous period, forming high mountains; dip southeast. Presidio del Norte.

This rock is similar to that from Cibolo creek, but more compact and less crystalline, and evidently has undergone a partial metamorphism.

A specimen from the rapids of the Del Norte is of a bluish ashen color, very compact and fine-grained, with numerous crystalline points and lines which mark the presence of organic bodies. Although no fossils can be recognized in their specific character, yet the rock is so precisely of the character of the carboniferous limestone in numerous western localities as to leave no doubt of its true age and geological position.

The specimens from Buffa-silla, marked "Aug. 10," consist of the following: two specimens of vesicular lava, one of compact breccia, enclosing fragments of lava, and several specimens of trap tuff, enclosing quartz pebbles and fragments, and becoming, in one specimen, a sort of friable breccia. Another specimen from the same locality, marked "Aug. 13," is a compact, volcanic breccia, composed mainly of fragments of various volcanic materials.

59. Vesicular lava, Buffa-silla.

A second similar specimen.

60. Compact lava, Buffa-silla.

61. Volcanic breccia, composed of fine white volcanic ashes, with pebbles and fragments.

62. Coarser breccia, with a coarser base than the preceding.

The compact lavas are represented as lying below, and the breccias between these and the more cellular lavas above. Sometimes there are several successive series of these beds.

63. Granitic or compact feldspathic lavas, with quartz and hornblende in small proportions. Three specimens from the cañon of the Rio Grande.

A specimen from the cañon of the Rio Grande, marked "Aug. 27," consists of a crystalline aggregation of quartz, feldspar, and carbonate of lime. Two other specimens, same date, from Puerto Peak, are granitic aggregations of quartz and feldspar, and appear much like a partially fused breccia.

64. Cemented volcanic ashes, with, occasionally, small vesicles, giving an amygdaloidal character.

Three specimens, showing variety (of 64.)

65. Breccia with a white base.

66. Lava, less compact than that below.

The series shows the succession of compact lava, breccia, and less compact, or vesicular lava above.

67. A fragment including part of a cavity in amygdaloid, with green quartz.

68. Brownish porphyritic rock. This has the common character of the porphyry of the region.

69. Crystallized peroxide of iron, connected with the trap or lava deposits.

70. Porphyritic granite, apparently of very modern origin.

71. Sienite or porphyritic granite, varying but little from No. 70. It contains dark smoky quartz.

72. Reddish porphyry or porphyritic trap, associated with the preceding specimens.

73. Compact argillaceous limestone of the Cretaceous formation.

74. Compact, close, and fine-grained argillaceous limestone of the Cretaceous formation.

75. *Exogyra texana*, from above the Pecos river.

76. Argillaceous limestone, with *Exogyra*, containing cavities filled with calcareous spar.

77. Fossil wood from Tertiary strata; Eagle Pass.

II. *Specimens from the country west of the Rio Grande.*

78. Sandstone, compact and fine grained. Cemialauke.

This rock is said to form a mountain range in connexion with the conglomerates. The specimens are not sufficient to determine satisfactorily the geological age of the formation.

79. Carboniferous limestone with fossil remains.

These specimens, (79,) from west of Salado, have evidently undergone partial metamorphism, though still preserving fragments of organic remains. One of them contains several imperfect shells, among which a Terebratula is distinguishable.

80. Porphyritic lava, connected with the preceding limestone; and breccia, connected with the same.

81. Compact trap, with a silicious incrustation covering the surface.

82. Amygdaloid.

An extensive district is represented as covered by rocks like 81 and 82, on the southwest of Frontera.

83. Amygdaloid, similar to the preceding; one hundred miles west of El Paso.

84. Specular iron ore. It occurs in loose masses, scattered over the Tertiary plains.

85. Chalcedony, associated with trap rocks.

86. Feldspathic lava, or compact trap tuff.

Rocks of this character are represented as forming the dividing ridge and summit of the Sierra Madre near the Gaudaloupe Pass.

88. Quartz rock; some portions are granular, showing the passage from an arenaceous mass to a compact homogenous quartz rock.

(This is, apparently a metamorphic stratified rock.)

A specimen from the summit of the Gaudaloupe Pass presents the character of rounded crystalline grains of quartz, in a paste of milky quartz. In many parts the granular structure is seen passing into the homogenous texture. This sandstone is associated with the carboniferous limestone.

89. A reddish colored stratified rock; apparently an altered shale becoming porphyritic.

90. An argillaceous sandstone; the granular structure gradually merging into a compact chalcedonic mass.

91. Conglomerate, associated with the preceding specimens, 89 and 90. The rock has the aspect of a Tertiary conglomerate.

92. A compact granular mass of feldspar and olivine.

93. A similar mass, colored by oxide of iron. The change of color perhaps due to infiltration of heated water.

94. Conglomerate, composed of quartz pebbles, trap, and other volcanic rocks, with much calcareous matter. The pebbles are somewhat angular. (A modern product.)

95. An earthy calcareous rock, associated with the preceding conglomerate.

96. Compact dark colored trap rock.

97. Talcous slate, with quartz veins.

98. Granite, fine, granular, consisting of quartz, feldspar, and mica, in nearly equal proportions, and having a more ancient aspect than the granite found associated with the trap rocks.

These two specimens (from the same locality) give the first indications of an approach to rocks of a character similar to those composing the Appalachian mountain chain; and which are like the products of metamorphic silurian strata.

III. *Specimens from the silver and lead-bearing rocks of the Corriletas.*

99. A compact silico-calcareous rock, with a few scales of mica. It appears to be an impure subcrystalline limestone, and is associated with other specimens of limestone. This is represented as forming the rock traversed by the veins of silver-lead ore.

100. Sulphuret of lead and silver.

101. Sulphuret and carbonate of lead.

102. Sulphuret of lead connected with a gray limestone.

103. Earthy carbonate of lead, said to contain silver.

104. Semi-crystalline limestone associated with the earthy carbonate of lead, which latter is represented as occurring in beds or veins, distinct from the sulphurets.

105. Limestone similar to the preceding, colored brown by oxide of iron.

106. Compact, silicious limestone, which has undergone some alteration from igneous action.

107. Compact, altered limestone, associated with the silver ores of the San Pedro mines.

A specimen said to be associated with the silver of the San Pedro mine is a greenish, impure limestone, with light colored or white crystalline points. The weathered surface presents minute cavities, and it has altogether the appearance of an ordinary greenstone. On testing by acids, it effervesces strongly, and is evidently highly calcareous.

108. Cretaceous limestone containing shells of Exogyra, &c., from the foot of the mountain in which the silver ores occur.

The cretaceous strata overlie the upper carboniferous limestones, and are shown to have been subjected to similar disturbances, so far as the elevation of the strata is due to such action.

109. Red oxide and green carbonate of copper.—Copper mines of New Mexico.

110. Green carbonate of copper.—Sonora.

111. Gray sulphuret and green carbonate of copper.—Copper mines of Presidio del Norte.

112. Sulphuret of lead and silver, with crystals of sulphate of lead.—Santa Rosa.

The specimens from Santa Rosa are from veins, and do not furnish any of the associated rock.

The specimens of rock from the Leon mine are a semi-crystalline limestone of a mixed gray and white color, with calcareous spar; and a crystalline limestone colored brown by oxide of iron. The other specimens from this locality are vein-stones or ores.

In the vicinity of the mines of Corriletas, the limestone has undergone still farther metamorphism, and some specimens which occur in the same connexion, and apparently of this age, assume a very crystalline character, and exhibit mica and some other minerals, which have been segregated from the mass during the progress of metamorphism.

The specimens of limestone from the Escandido mines include one of a yellowish white color and crystalline texture, containing disseminated crystals of iron pyrites: this may be a vein-stone. Another specimen is of very compact, bluish, granular limestone, with thin pressed veins of spar, evidently having undergone some metamorphic action. This is labelled as coming from the foot of the mountain adjoining the mines. Other specimens marked as from the same locality contain large numbers of fossil shells, but in such a condition as to afford very unsatisfactory means of determining their age. They present, however, many features like those of the cretaceous limestones, and are probably beds of that formation, which have undergone partial metamorphism.

B. SPECIMENS COLLECTED ON THE ROUTE FROM THE PACIFIC COAST EASTWARD, INCLUDING THE TERTIARY OF THE COAST AND THE METAMORPHIC ROCKS OF THE CORDILLERAS; THE TERTIARY OF THE GREAT PLAIN EAST OF THE CORDILLERAS, AND THE METAMORPHIC ROCKS OF THE ISOLATED MOUNTAINS IN THE GREAT PLAINS.

IV. *Specimens from the coast Tertiary belt, from the neighborhood of San Diego.*

1. Gray micaceous sandstone, with more or less of argillaceous matter, friable, or more or less compact.
2. Calcareous beds with shells, Turritella, Pectunculus, &c.
3. A fine chalk-like, tufaceous deposit, occurring in isolated beds.
4. Lignite, associated with clays and sands.

V. *Tertiary formations spreading over the plain east of the Cordilleras.*

1. Sands and marls with clays, all more or less calcareous; represented as forming extensive beds of considerable thickness, and cropping out in bluffs of several hundred feet high.
2. Shells of *Ostrea vespertina*, from the beds of the preceding series.
3. Calcareous tufa; forming isolated masses or deposits.
4. Gypsum—Selenite. This mineral occurs in the clays and marls of the formation.
5. Common salt, forming on the borders of lakes from evaporation. The soil is more or less permeated with saline matter, which is carried downwards to the depressions in which occur the small lakes having no outlets.

6. Sandstone. A fine-grained, friable, micaceous sandstone, occurring above the marls and clays, and represented as attaining a thickness of from 100 to 200 feet.

The sandstone contains nodules of clay, which are often large and flattened, forming an irregular or interrupted layer. These nodules are frequently surrounded by pebbles or small gravel. These pebbles consist of quartz, porphyry, greenstone, jasper, &c., and sometimes form layers of conglomerate. From the evidences of drift action afforded in the specimens, it is probable that the formation may at some points present extensive beds of conglomerate.

This sandstone is precisely of the same character as the Tertiary sandstone of the Mauvaises Terres of Nebraska.

7. Coarse sand and small pebbles cemented by calcareous matter, forming a conglomerate which has a thickness of 30 or 40 feet.

8. Fossil wood—an erratic mass found upon the plains.

9. Vesicular lava, having the cavities filled with earthy matter, and embracing small shells like Ceritheum, but too imperfect to be specifically identified.

The table-land occupied by this Tertiary formation forms the plateau in which the rivers take their rise.

V. *Specimens from the Coast Range.*

1. A somewhat vesicular trap or greenstone, containing spots and blotches of soft green earth.

1. Greenstone porphyry.

VI.—*Specimens from the westerly part of the Cordilleras.*

1. Chloritic rock, having a compact or scarcely laminated structure.
2. Chloritic or talco-chloritic rock, with hornblende, etc.
3. Black mica, with quartz veins.—Pine ridge, 16 miles E. of San Luis Rey.
4. White quartz, with schorl.
5. Quartz and feldspar; granitic in its structure, and containing schorl.—Near Santa Isabel.
6. Feldspathic granite, very similar to the preceding specimens.—Near Acapulco.

VII.—*Specimens from the central portion of the dividing range.*

1. Granitic or sienitic rock, composed of quartz with black hornblende in blotches and a little mica.—From the bare peaks of the Cordilleras, near the boundary line.

2 Feldspathic granite, somewhat gneissoid.

3. Feldspathic gneissoid granite.

4. Gneiss.

5. Hornblende rock; dark colored.

This rock is very similar in character to much of the rock of the Green mountain range.

6. Fine-grained syenitic rock, with hornblende in crystals on the surface.

The specimens enumerated above, from 2 to 6 inclusive, are evidently from the same formation of metamorphic rocks in the exposures of the different beds.

7. Rose quartz; from a loose mass, though probably derived from this metamorphic belt.

8. Black tourmaline; a loose mass.

9. Crystalline quartz, with black tourmaline.—Near the dividing ridge of the Cordilleras; east from San Diego.

10. Feldspathic granite, with mica in large plates. The locality south from No. 1 of this series, and belonging to the same (dividing) range.

VIII.—*Specimens from the eastern slope of the Cordilleras.*

1. Coarsely crystalline granite, with much mica and feldspar.—Lower California.
2. Similar to the last, but with a less proportion of feldspar.—Lower California, near the boundary line.
3. Talcose slate, with Anthophyllite.
4. Quartz in veins in the talcose slate.

IX.—*Specimens from the isolated mountains in the great plain of the Cordilleras, near the mouth of the Gila, on the west side of the Colorado River.*

1. Syenitic rock, composed of hornblende and feldspar.
2. Similar to the last, but finer grained.
3. A granitic mass, composed of quartz, feldspar, and mica, with black tourmalines.
4. A granitic mass, consisting chiefly of quartz with laminæ of white mica The quartz contains garnets.
5. Gneiss or mica slate, finely granular and laminated.
6. Epidote rock; crystalline.
7. Epidote with talc; (two specimens;) the talc in thin minute scales, and the epidote finely granular.
8. Epidote and talc; the epidote granular, but arranged in laminæ.

IX.—*Miscellaneous specimens not numbered.*

Specimens designated as follows:

"August 25," compact and amygdaloid traps.

"August 29," marked as the lower stratum, is amygdaloid, having the appearance of fine volcanic ashes, loosely cemented, and containing a few cavities filled with crystalline matter, and others empty.

"September 16," volcanic tuff.

"September 17," green quartz in a cavity of amygdaloid.

"September 30," specular iron ore connected with volcanic rocks.

"October 7," reddish, porphyritic lava.

"November 8, Mount Carmel," coarse syenitic aggregate.

"November 10," reddish vesicular porphyry.

"March 2, 1852," siliceous rock, apparently indurated trap tuff.

"March 26, 1852," granitic lava, or trap tuff, with crystals of feldspar, mica, &c.

"Summit of San Luis Mountains," an indurated tufaceous mass, with cavities lined with quartz.

"Mouth of Guadaloupe river," semi-metamorphic red shale.

"Conglomerate, mouth of Guadaloupe river," breccia, probably of volcanic origin.

"Santa Cruz Pass," compactly granular feldspathic rock, containing minute grains of magnetic oxide of iron. Another specimen is of vesicular trap tuff, colored red by oxide of iron.

"Rio Santa Cruz, above Tilbac," semi-indurated volcanic ash; also a specimen of coarse breccia.

"Igneous rocks west of Salado"—one specimen is compact, feldspathic lava; the other compact, coarse breccia.

"Laguna Santa Maria," finely vesicular trap, with siliceous incrustation.

"Twenty-five miles southwest of Frontera," highly vesicular trap or amygdaloid.

"Baranca," a granular amygdaloid.

The enumeration of this collection of specimens enables us to deduce some general conclusions of great interest regarding the geological structure of the country between the Gulf of Mexico and the Cordilleras range of mountains. The specimens from the eastern part of this range, taken in connexion with what we know of its character in other places, and of the geology between this range and the Pacific ocean, are sufficient to give a very correct idea of the intervening space.

A broad belt along the coast of the Gulf is occupied by deposits of very modern geological age, which may be referred to the same period as the drift and alluvium. This deposit consists of water-worn materials—as sand, gravel, pebbles, &c., which have been spread over the surface in a very regular and even manner. The general elevation of this belt is 300 feet above tide water, and varies little in its height for many miles in extent.

In several places the denudation of this deposit discloses beneath it formations of the earlier Tertiary period. Approaching the borders of the high table-land which commences at the head of navigation on the rivers, the cretaceous formation appears at numerous points in the river beds and banks, and elsewhere where the superficial accumulations are removed.

From the commencement of the table-lands westward, the specimens show the occurrence of a broad belt of the cretaceous formation, interrupted here and there by isolated dykes, or mounds of trap, or other igneous rocks of modern age. Basins of Eocene, marine Tertiary, likewise occur at intervals, resting upon the cretaceous beds. The specimens of the latter formation consist of limestones, some of them extremely compact and dark, and others light colored and friable. Various admixtures of these with more argillaceous matter, and greenish, calcareous sands, sometimes partially indurated, are of frequent occurrence. The numerous fossils collected from different localities leave no doubt in regard to the age of this formation.*

In localities where the igneous rocks are protruded through the beds of this age, a greater or less degree of metamorphism has taken place. Sometimes we find a partial or entire induration of the contiguous masses, and often their metamorphism is so great as to render it difficult to distinguish their age and relations from a simple examination of specimens.

Towards the west the igneous rocks, which first appear in small, isolated knolls, gradually

* I should not omit to notice in this place the very valuable and interesting work of Dr. F. Rœmer upon the fossils of the chalk formation in Texas, "*Kreidebildungen von Texas*," &c. This gentleman passed more than two years in the United States, a considerable part of which was spent in Texas. Previous to the publication of this work he had published a description of that country, with a geological map, &c.

The collections now under consideration, though for the most part made at a distance from the principal localities cited by Dr. Rœmer, correspond to a great extent with those described by him, and corroborate in the most satisfactory manner his views of the general geological structure of the country.

assume more importance, and extend into long belts. In the Limpia range these rocks present the character of a mountain chain, having an elevation of 6,000 feet, and extending several hundred miles north and south. The specimens from this range present the characters of eruptive and metamorphic rocks. Notwithstanding the syenitic texture of some of the beds, they have still a modern aspect. The different minerals are quite distinct from each other, not blended and imbedded as in the older metamorphic rocks, and their mode of aggregation is also unlike. In addition to this, the occurrence of igneous products of very modern age, which are intimately associated with these rocks, and apparently prevail in great quantity, induce us to regard all these as belonging to a system of eruption and of elevation of very modern date.

We may, however, inquire what other evidences, if any, we have in the surrounding rocks as to the age of these igneous mountain ranges. The great table-land formed of the cretaceous rocks has on its eastern margin an elevation of not far from 1,000 feet. The surface of the country gradually rises to the westward, and near its junction with the igneous rocks of the Limpia range they have an elevation of 3,000 or more feet. On approaching the range, also, we find these beds of cretaceous age dipping at a high angle in various directions, showing great disturbance of the beds, apparently due to the elevation of intruded igneous masses. The beds of cretaceous rock have in some instances been indurated, and otherwise affected by the proximity or contact of igneous masses.

We have, therefore, not only evidence of the general elevation of the country towards the great central range in the inclination of these beds, but we have the positive evidence of local disturbance and change due to the intrusion of these igneous masses which form isolated points or mountain chains.

Beyond the Limpia range, in the neighborhood of El Paso, we have cretaceous rocks, containing numerous fossils. These beds rest upon carboniferous limestone, and all have a westerly dip—the carboniferous strata dipping at a much higher angle than the cretaceous. The rocks of both periods are complicated with volcanic and other igneous rocks; and in some instances the latter have been protruded beneath the cretaceous beds, and rest upon the carboniferous limestone, which is but partially altered. The cretaceous beds of this locality are about 4,000 feet above tide water.

Still farther west, in the vicinity of Corrilitas, cretaceous beds occur in connexion with partially altered limestones and igneous rocks, having an elevation of nearly 5,000 feet above the level of the sea. This is the most westerly point at which any cretaceous fossils have been found on the line of this expedition.

The occurrence of cretaceous deposits in this region is of much interest when taken in connexion with similar discoveries further to the northward. Captain Frémont, in his explorations of 1843 and 1844, brought cretaceous fossils from the eastern slope of the Rocky mountains, Smoky Hill Fork of the Kansas river, in latitude 39°, longitude 105°. In the explorations of 1846 and 1847, Lieutenant Abert collected specimens of the same species of cretaceous fossils, (*Inoceramus mytiloides*, = *I. problematicus*,) at Poblazon, on the western slope of the Rocky Mountains, in latitude 35° 13′, longitude 107° 0′ 2″.*

* Professor Bailey, who identified the fossils in Lieutenant Abert's collection, makes the following remarks: "The fossils from Poblazon consist of gigantic Hippurites, casts from the cells of several species of Ammonites, valves of Inoceramus, identical with a species figured in Frémont's Report, pl. IV, fig. 2,† casts of small univalves and bivalves too imperfect for

† *Inoceramus* (*mytiloides*) *problematicus*.

The same species of *Inoceramus* was brought from between the Big and Little Blue rivers, (tributaries of the Kansas river,) by Captain Stansbury. A collection from several points in Arkansas, made by Colonel Frémont in his late expedition, and sent to me for examination in 1854, contains also specimens of *Inoceramus problematicus*, associated with a few other fossils.

The cretaceous fossils which occur in the vicinity of Corrilitas correspond in position, being on the eastern slope of the Rocky Mountains in nearly the same meridian of longitude' and between 31° and 32° of latitude. In each of these explorations the points mentioned were the farthest west at which cretaceous rocks with fossils were obtained.

The identity of fossils, the occurrence of the same species of Inoceramus in all these localities, and its association at Poblazon with Hippurites, as in the collections of the Boundary Survey, indicate very clearly the same geological horizon for the strata of all these localities from the Kansas river to New Mexico.

The dip of the strata in the localities is influenced by the igneous rocks in immediate proximity, and is therefore variable, often inclining to the west; while the general dip of the formation is in the opposite direction.*

To the west of the last named localities there occur various stratified, partially metamorphic rocks, some of which may be of cretaceous age; but the information possessed warrants no more than a probable inference. One of the specimens is a somewhat coarse and rather loosely aggregated calcareous gray sandstone, and another is a partially metamorphic silicious slate.

The principal features developed by this collection show the existence of a broad belt of cretaceous rocks, in almost uninterrupted continuity, along the Rio Grande, from below Laredo to beyond San Vincente. On either side are igneous rocks occupying a greater or less extent; and beyond the junction of the Rio Pecos these igneous belts become of more frequent occurrence and of greater extent. The older tertiary deposits occupy isolated basins in the cretaceous formation, and both are covered indiscriminately by the alluvium.

In many places, these drift or alluvial deposits, consisting of waterworn materials, with saline efflorescences, gypsum, &c., are spread out over large areas of the cretaceous formation which forms the fundamental rock of the Llano Estacado or Staked Plain.

The almost constant occurrence of the carboniferous limestone, with these igneous and metamorphic belts, along a great north and south extent, taken in connexion with our knowledge of the existence of this formation on the west and northwest of the Mississippi valley and in Arkansas, offers almost conclusive evidence that nearly or quite all the intermediate space is occupied by the same strata underlying the cretaceous formation.

We already know of a similar association of the carboniferous limestone, over a large extent of country, in the vicinity of the Great Salt Lake, and at intervals farther to the south; and the facts, in connexion, afford a very probable inference that it occurs in similar associations from the southern boundary of the United States, or latitude 28°, to above the 42d parallel.

determination, and teeth of sharks. These fossils prove that the strata from which they were taken belong to the cretaceous formation. The existence of vast beds of this formation on the east side of the Rocky Mountains, and extending from the upper Missouri to Texas, is well known. The occurrence of the same formation on the western side of the primary axis of the Rocky mountains, is quite interesting."

"The dip of the rocks at Poblazon is to the west, or from the Rocky Mountains; and this proves that these mountains have been elevated since the deposition of the cretaceous beds. It is, therefore, probable that the cretaceous beds on both sides of the Rocky Mountains were made by the same ocean."

* The inferences in regard to dip, &c., are founded on observations and sections furnished by Dr. C. C. Parry.

The relative position of these cretaceous beds is precisely the same throughout Texas that it is along the valley of the Mississippi river, in the States of Tennessee, Arkansas, Illinois, and Missouri, where they rest upon the upper carboniferous strata.

In an economical point of view, the most important results shown by this collection are the almost constant association of metalliferous products at the junction of the igneous with the metamorphic rocks of the carboniferous period, or perhaps sometimes with metamorphic rocks of more ancient date.

The collection of silver lead ores and copper ores, from different veins, with the associated rocks, show that they are always near the junction of the igneous formations, and the superincumbent more or less altered limestones. The metalliferous veins, it would appear, always penetrate the limestones, which vary in character from gray or grayish blue granular beds with fossils, to light colored or nearly white crystalline limestones. The specimens which can be identified are clearly of carboniferous age, though some erratic specimens show that the older Palæozoic limestones may enter into this combination; and possibly some of the cretaceous beds have become so altered as to be undistinguishable from the older rocks, though we have yet had no proof of extensive metamorphism in rocks of this age.

These circumstances, nevertheless, do not affect the general inferences regarding the metalliferous character of the rocks at or near the junction of the two systems. The facts before us warrant the conclusion that the conditions enumerated apply not only to the region actually travelled over, but also to the highly metalliferous regions farther to the south in the same range. These facts also suggest the importance of a more careful examination of this range in its northern extension, which we already know to have the same geological constitution, but which has scarcely been explored with a view to its economical resources.

OBSERVATIONS UPON THE IGNEOUS AND METAMORPHIC ROCKS, AND ASSOCIATED MINERALS, IN THE BOUNDARY SURVEY COLLECTIONS.

The preceding catalogue of specimens, with observations upon their character and geological age, and a resumé of their geographical distribution, may very properly be followed by some notice of their relative positions in the series, and their correspondence with, or difference from, others of the same age in other parts of the country.

From time to time, and from various sources, we have learned that large areas of the central portion of this continent are occupied by rocks of igneous or metamorphic character; and that the plains and valleys present geological formations of different and more recent periods. We have also been made aware of the entire distinctness, in character and origin, as well as geographical separation, of the great mountain chain of the Cordilleras, or Sierra Nevada of the North, from the more easterly ranges of the Rocky Mountains.

Physically, the great central mountain region, or Rocky Mountain chain, with its subordinate ranges, is clearly as distinct from the western chain, notwithstanding there may be numerous isolated peaks and short broken ranges, which form a partial connexion between them. Still, again, the Sierra Nevada and the coast range are recognized as geographically distinct.

Geology has likewise proved these several mountain ranges to be of different origin and of different age. The Cordilleras, or Sierra Nevada, and the subordinate ranges, or isolated mountains dependent upon that stupendous chain, are all of the older metamorphic rocks, consisting of stratified rocks of Palæozoic age, silurian, devonian, and perhaps, to some extent, of carboniferous strata, which have been changed from their original condition, and finally elevated into mountains. The lithological character and mineral products are identical with the rocks of the Appalachian chain, which form the great elevation from Canada and Nova Scotia to Alabama, on the eastern side of our continent. Their lithological characters and mineral products correspond likewise with rocks known to be of that age in other parts of the world.

The series of specimens in the boundary collections, and the specimens in other collections, brought from this mountain range, exhibit all the varieties of mineral materials and differences of aggregation presented in a series of the rocks of the Appalachian formations. The auriferous gravel of California is derived from the quartz veins in the slates and other rocks of the Sierra Nevada, as the auriferous gravels of Canada, Virginia, the Carolinas, and Georgia are derived from the quartz veins of the Appalachian rocks. The auriferous quartz veins of California are the same in character, in age, and origin, as those traversing the metamorphic rocks of the great eastern chain from Canada to Georgia.

There are even stronger, though more subtle, analogies between the rocks and minerals of these widely distant mountain regions, when submitted to the researches of the chemist. Rocks and compound minerals, while known by the same names, are often found, on careful analysis, to possess different proportions of certain elements; or they may in one case contain an elementary mineral substance not known in the other. Now, even in this regard, the researches of chemistry have proved that certain mineral products of the one mountain chain are precisely similar to the same in the other. And we might go still further, and show that the order of succession among beds of a certain character is the same in both mountain chains, and prove also, by dynamic and chemical laws, that it could not have taken place in any other order.

The present occasion does not require the details of comparison between these two ranges of the same age. Still, it is not a little interesting to know that two mountain chains, produced from the metamorphism of series of strata of the same age, now form, the one the eastern, and the other the western, outlines of our continent. The one has a direction from northeast to southwest, and the other, almost at right angles, from the northwest to the southeast, giving us the great breadth of continent at the north, and the narrow southern extremity.

The coast range of mountains presents us with quite distinctive features in the specimens, and we know from many sources that it consists of recent igneous rocks and metamorphic strata of very modern age, the igneous products being chiefly greenstone or basalt, amygdaloid, and materials of similar character. Further east, the Cordilleras offer a striking contrast in the collections to those made along the route travelled from the coast of Texas to the westward. From the coast to the Rio Grande, the specimens from the Limpia range, from the Sierra Madre, and the Organ Mountains present no character similar to those from the Cordilleras. The granites are all of different aspect, with glassy feldspar, occuring in connexion with known volcanic products, as porphyry, greenstone, and mixtures of quartz, feldspar, and olivine, etc.

There are among these no granites assuming a gneissoid structure; no granites with shorl, tourmaline, or garnets; no talcous (pholerite) slates, chloritic or mica slate rocks, as in the Cordilleras. The lithological aspect of the two collections is at once conclusive of their different age and origin.

Whatever the Rocky Mountains may offer in other parts of their range, that passed over in the boundary survey gives no indication of the occurrence of the older metamorphic rocks. Indeed, the materials of purely igneous origin so largely preponderate, that the few metamorphic specimens appear quite subordinate; while the observations accompanying the igneous specimens prove that they form nearly entire mountains which are crossed upon the route.

We are aware that further to the north there are extensive mountains, which bear rather the character of metamorphic than of igneous products; but even these do not resemble the metamorphic rocks of the western chain.

In the specimens from this range, we see the predominating influence of volcanic action, and the result of the same action in the influence of heated waters holding silex in solution, by which the more porous masses have been penetrated and become solid, or so changed in color and condition that there is an almost infinite variety of these products of one prime source.

OBSERVATIONS ON THE CARBONIFEROUS LIMESTONE OF THE BOUNDARY SURVEY COLLECTIONS, AND ITS RELATIONS WITH THE CARBONIFEROUS LIMESTONES OF THE MISSISSIPPI VALLEY.

The carboniferous limestone, so often mentioned in the preceding pages, and which has been usually referred to in published reports as "Carboniferous limestone," and as "Lower carboniferous limestone," is actually of the same age as the coal measures. This point we have but lately had the means of satisfactorily determining.

Several species of fossils were known to characterize this formation over a wide extent of country, and from their associations the rock was referred simply to "carboniferous limestone,"* without distinguishing the order of position among the different members of that series. Among these species were several known to occur in the coal measures of Ohio, Indiana, Illinois, Iowa, and Missouri, while none of them were characteristic of the lower carboniferous limestones.

In the Missouri Geological Report of 1855, Professor Swallow has placed the limestones and shales of Weston and other localities, which contain these fossils, in the upper coal measures. At the same time, some of them are known to occur in the lower coal measures; and, with our present knowledge, we are constrained to believe that certain species occur both in the upper and lower coal measures of the west.

In order to understand fully the relations of this higher carboniferous limestone of the west to the other members of the series termed carboniferous, it is necessary to present the following section of these rocks, beginning with the upper member:

	Section of the carboniferous limestones and the coal measures in the valley of the Mississippi.	LOCALITIES.
VII.	Shales, shaly sandstones, sandstones, and seams of coal, with shaly and more compact limestone, constituting the *upper* coal measures. This limestone is designated as the *upper carboniferous limestone*, and constitutes the carboniferous limestone of the Rocky Mountains.	*Localities of the upper carboniferous limestone*, Ohio; Indiana. Illinois; Weston and Bellevue, Missouri; Great Salt Lake, Utah Territory; near Santa Fé, and at the Pecos village, New Mexico, etc.
	Coal measures below the limestone, being the *middle* and *lower* coal measures of the Missouri report, and the *lower* coal measures, in part, of Ohio and Pennsylvania.	Ohio, Indiana, Illinois, Missouri, etc.
VI.	—Kaskaskia, or Upper Archimedes limestone	Kaskaskia and Chester, Illinois; St. Mary's, Missouri, etc.
V.	—Gray, brown, or ferruginous sandstone	Below St. Genevieve, Missouri, between Prairie du Rocher and Kaskaskia, Illinois.
IV.	—St. Louis limestone, or concretionary limestone	St. Louis, St. Genevieve, Missouri; Alton, Illinois; highest beds below Keokuk, Iowa.
III.	Arenaceous bed Warsaw, or second Archimedes limestone Magnesian limestone	Warsaw and Alton, Illinois; Spergen Hill, Bloomington, Ind.
	Beds of passage, shale or marl, with geodes of quartz, etc.	Keokuk, Iowa; Warsaw, Illinois
II.	—Keokuk limestone, or Lower Archimedes limestone	Keokuk, Iowa; Quincy, Illinois; above St. Genevieve, Mo.
	Beds of passage, (cherty beds,) 60 to 100 feet	Rapids of the Mississippi, above Keokuk
I.	—Burlington limestone	Burlington, Iowa; Quincy, Illinois; Hannibal, etc., Missouri.
	Oolitic limestone and argillaceous sandstone of the Chemung period.	Burlington, Iowa; Hannibal, Missouri

* Dr. Owen in his report upon the Chippewa land district, gives numerous sections of the carboniferous limestone in the Mississippi and Missouri valleys, and its connexion with beds of coal; but he does not speak positively with regard to the position of this rock or its distinction from the carboniferous limestones below.

The limestones in the lower part of the section are those usually termed "carboniferous limestone." The group consists of distinct members, each marked by numerous characteristic fossils, and the whole together representing the phases of a calcareous formation, going on in an ocean, where the conditions of its bed and its limits were subjected to change.

The limestones of this period are well developed in the valley of the Mississippi, from above Burlington, in Iowa, and Oquaka, in Illinois, as far south as below the towns of Kaskaskia and Chester, on the Illinois side, and St. Genevieve and St. Mary's, on the Missouri side. Several of the members are known in Indiana, and one or more in Kentucky, Tennessee, and Alabama, and also in Arkansas. Throughout all this region these limestones, whether developed as the full series or in a single member, underlie the coal measures proper.

In all the collections which I have examined from Texas and New Mexico, and from points further north in the same line, and particularly in the collections made by Captain Stansbury, on his route from the Missouri to the Great Salt Lake, and in that region, I have never observed fossils which are characteristic of any member of the lower carboniferous limestone. We have, thus far, no evidence of the occurrence of lower carboniferous strata among the Rocky mountains; while at intervals from the northern limits of the United States along the range of the Rocky Mountains, and both east and west of the principal range, we have the upper carboniferous limestone everywhere more or less perfectly indicated by its characteristic fossils. Among these are *Spirifer cameratus*, *S. lineatus*, *Terebratula subtilita*, *Productus Rogersi*, *P. semireticulatus*, *Zaphrentis Stansburyi*, and others. From a recent comparison of specimens from Ohio, Illinois, Iowa, Missouri, Kansas, Texas, and New Mexico, I find the same association of species from numerous localities.*

In the eastern and northern part of the State of Ohio, (and perhaps extending into Pennsylvania,) there are thin bands of limestone associated with the coal measures. These beds are usually shaly in character, often separated by wide vertical joints, and weather to a brown color. Although recognized at numerous points, I am not aware that these beds have been regarded as continuous, though they are doubtless indications of a continuous formation. A comparison of fossils from numerous points in the coal measures of the West, shows very conclusively that one or more of these beds of limestone are continuous, or at least that the same association of fossil species occur at so many points as to leave no doubt of a similarity in the conditions of the ocean bed over a wide area now occupied by the coal measures.

One of these bands of shaly limestone, containing throughout the same species of fossils, may be traced from northeastern Ohio, or even from Pennsylvania, through Indiana, Illinois, Iowa, and Missouri, becoming in the latter State, and in the adjoining parts of Nebraska and Kansas, an important limestone formation, and constantly increasing in a westerly direction until it becomes the prominent limestone of the Rocky Mountain range.

According to the report of Captain Stansbury, and from specimens brought by him from the Salt Lake region, we learn that it there forms extensive mountain ranges or at least that it is

* It was from a limestone in the coal measures of Ohio that Dr. Hildreth procured several species of fossils which are described by Dr. Morton in the American Journal of Science, vol. xxix. The *Spirifer cameratus* of that paper appears to be identical with one described by Dr. Roemer as *S. Meusebachanus*, and by the writer as *S. triplicatus*, in Stansbury's report, and the same is referred, with doubt, by Dr. Owen to *Spirifer fasciger* of Keyserling. The species presents much variety in different localities, but a comparison of specimens from Ohio, Iowa, Missouri, Texas, and New Mexico, leads me to infer that they are all of a single species first described by Dr. Morton. It is possible that further comparisons may show the occurrence of two closely allied species, but more extensive collections are required for this purpose.

the most conspicuous rock of the north and south ranges in the vicinity of the Great Salt Lake. The limestone from these localities is a dark-blue, compact rock, often, in specimens, gray and subcrystalline, and sometimes with sparry veins.

This limestone, identifed by its fossils, is found in the collections made near Santa Fé, New Mexico, at the Pecos village, the Mogollan Mountains, at El Paso, upon the river San Pedro, and the numerous other localities. From a sketch and the notes of Dr. Parry, before alluded to, this limestone forms a conspicuous part of some of the mountains along the boundary line. There can be little doubt that the same limestone occurs much further to the southward, and that it constitutes the principal calcareous formation of that part of the country, whether in an unaltered or in a metamorphic condition. It is, as already stated, the limestone traversed by veins of silver lead, from which specimens have been brought in the boundary collection.

The collections of Dr. Roemer, from Texas, indicate very clearly the occurrence of this limestone at the places examined by him; and he gives no figures of species belonging to lower carboniferous limestones.

From the massiveness and compact texture of many of the specimens from the southwest, and the subcrystalline character of others, we are prepared to find that this rock has become much more extensively developed than in the northeast, or even in Missouri or Kansas; and it would appear, also, that the shaly beds which accompany the limestone in these localities and are often more conspicuous than the limestone itself, have diminished so far as to form no striking feature in the far west and southwest. We are not able to learn that it is there ever accompanied by coal, and it is presumed that the shaly and sandy materials associated with the coal, as well as the coal itself, have thinned out in that direction, or become of such tenuity as to be of no importance.

The relations of this limestone to the lower coal measures, in the States bordering the Mississippi river, render its occurrence a subject of interesting economical inquiry. Since we know that the most extensive and valuable beds of coal in the west are of the lower coal measures which lie beneath the upper limestone, they may still be found to underlie the upper carboniferous limestone of the Rocky Mountains, as they do the same limestones in Kansas, Missouri, Iowa, Illinois, and Indiana. Thus far I am not aware that any inquiries of this kind have been instituted in the explorations and surveys already made.

Having thus briefly described the range of the upper carboniferous limestone, we may now take a comprehensive view of its conditions and extent. We find that during the coal period, in the States east of the Mississippi river, thin strata of limestone, or calcareous shale, were deposited. These are charged with brachiopoda, of genera characterizing the carboniferous limestone below the coal measures, though of species distinct and peculiar. So thin and insignificant is this formation, that we can scarcely regard it as the product of a wide and deep ocean. Tracing it westward, however, its importance increases; from being entirely subordinate to the coal measures proper, and scarcely affecting the character of that formation, it becomes a characteristic mass; the calcareous mud mingles with the coal, and the latter becomes subordinate to the limestone and calcareous shales. Still further west it is a vast limestone formation, next in importance to the great calcareous formation below the coal, or lower carboniferous limestone formation.

The conditions favorable to the production of an extensive deposit of marine limestone are not such as usually accompany the production of coal. In the present instance, the ocean, depositing the great limestone formations previous to the coal period, occupied to a great extent the present area of the coal measures which succeeded. Land plants in excessive growth, estuary or shallow water shells attend the production of the coal and its associated strata. We begin thus to comprehend the truth that, during the period of the great coal formations of the Appalachian, and the Mississippi valley, there existed a broad ocean at the far west and southwest, in which these calcareous deposits were in course of formation ; that during the oscillations which we know to have occurred throughout the coal period, there was a time when the whole area became depressed so as to allow the waters of the southwestern ocean to flow over all the coal-measure area, or, at least, as far northward and eastward as the northeastern part of Ohio ; and from hence is derived the limestone under consideration. The calcareous bands deposited along the northeastern margin of this ocean, we now find interstratified with seams of coal, and beds of shale and sandstone containing land plants; while, as the waters deepened towards the southwest, the formation exhibits the differences of character which we would necessarily expect to find in an ocean deposit.

The evidence of the existence of this ocean in the far west and southwest, during the coal period, amounts to almost a proof that the conditions of that area, which now constitutes a part of the continent, were never such as to admit of the production of coal plants, and the deposit of such materials as make up the coal measures, at least during the latter part of the coal period. In regard to the earlier part of that period, or the time in which the lower coal measures were formed, we have not, as I conceive, at present, the means of fully deciding what were the conditions in the central and southwestern part of our continent.

OBSERVATIONS UPON THE CRETACEOUS STRATA OF THE UNITED STATES, WITH REFERENCE TO THE RELATIVE POSITION OF THE FOSSILS COLLECTED BY THE BOUNDARY COMMISSION.

The list of fossil species from the localities visited by the Boundary Commission shows so large a number identical with those described and figured by Dr. Roemer in his *Kreidebildungen von Texas*, that we cannot doubt the occurrence of the same beds throughout the whole extent surveyed, as far as the neighborhood of El Paso and Frontera. These collections, made at intervals over so wide an extent, would be likely to give us some representative species from different and successive beds of the formation, should it there exhibit similar subdivisions as are elsewhere known in this formation, in other parts of the country. With the exception of two species, they are all distinct from those known in the cretaceous formation of New Jersey and Alabama, where the fossils have been most carefully studied. They are equally distinct from the species occurring in Nebraska; while those from the last-named region present so many species in common with New Jersey and Alabama, that we cannot doubt the general equivalency of the beds in these distant points. The species known from Tennessee are likewise identical with New Jersey species to a great extent, leaving no doubt as to the exact equivalency of the formation in the two localities.

The cretaceous formation, as known in New Jersey, can therefore be traced by the Atlantic coast to Alabama, and thence into Tennessee, and even southern Illinois; and though not yet followed continuously to the northward, it is nevertheless recognized in Nebraska by numerous identical species of fossils.

When we carry forward our investigations in a southwesterly direction, however, we soon lose, to a great extent, the evidence of identity in the fossils; and in Arkansas the *Exogyra costata*, *Ostrea vesicularis*, and *Trigonia thoracica*, are almost the only species identical with those known on the east of the Mississippi river, and in Nebraska. At the same time, other species occur in considerable abundance, which are of decidedly cretaceous character, leaving no doubt of the existence of that formation, though we have lost the evidences which guide us in more eastern localities.

Since this change in the character of the fossils is quite observable as far north as Fort Washita, in Arkansas; and since the types of the green sand of New Jersey and Alabama extend as far north as Tennessee and Illinois, it is clear that the change is not due to climatic influence or to geographical distance. It would moreover be unreasonable to suppose that such a change in the nature of the sediment had taken place as to destroy within this short distance all the forms of life so well known further east, and replace them with others adapted to the different condition. Indeed, we are not informed that there is any great change in the lithological character of the strata; though it is true that the cretaceous beds of Arkansas, Texas, and New Mexico, (as we judge from the specimens,) are more calcareous than those of New Jersey and Nebraska. But they are not more so than in Alabama, where the "Rotten limestone" attains a thickness of 400 feet, and contains species common to the regions just referred to.

It is not due therefore to difference of latitude, or to a change of conditions in the sediment, that we have this difference in the organic remains of the formation; but it is doubtless true that this region of the cretaceous formation of the southwest, which has yielded nearly all the fossils, represents a *different epoch* in the *cretaceous period* from those beds further east and in the northwest, of which the organic contents are better known.

The relations of that part of the cretaceous formation, which is developed in Texas and New Mexico, to the same formation as known on the east of the Mississippi river and in Nebraska, becomes a matter of much interest and importance.

The various examinations in Texas and in Arkansas, as well as along several lines of survey, do not give us any sections of these beds showing their relations with other formations, or indications that there may be more than a single member of the cretaceous formation from which all these fossils have been derived.

Before attempting to theorize in regard to the probable cause of this difference in the fossils of the cretaceous strata at these distant points, we may bring together in a general manner the results of investigations made at various points and at different times, which may serve to throw some light upon this question.

In the earlier investigations of the cretaceous formations of New Jersey and other parts of the United States, Dr. Morton subdivided the whole into three groups or divisions.

First Group.—Upper cretaceous strata.

Second Group.—Medial cretaceous strata.

Third Group.—Lower cretaceous strata.

The upper division embraced the Nummulite limestone of Alabama, being especially characterized by the presence of *Plagiostoma dumosum, Nummulites Mantellii,* (*Orbitoides Mantelli.*) This rock is now regarded as belonging to the older Tertiary formations.

The medial division was regarded as contemporaneous with the white chalk of Europe.

The lower division embraced the " ferruginous sand deposits of the Atlantic States, extending from Martha's Vineyard to South Carolina and Alabama, and into Mississippi, Arkansas and Missouri."

These strata were at that time regarded as contemporaneous with those which lie between the white chalk and oolite in Europe.

The foregoing subdivisions were proposed by Dr. Morton in some " additional observations" appended to his " Synopsis of the organic remains of the cretaceous group of the United States," and published in the Journal of the Academy of Natural Sciences in 1842. Accompanying this classification of the cretaceous formation is a list of fossils from each of the subdivisions, including all those which had been described up to that period.

Professor Rogers, in his report upon the geology of New Jersey, in 1840, proposed a division of the cretaceous formation of the State into five members. These subdivisions, however useful they may have been topographically, are not accompanied by the palæontological evidence necessary to enable us to determine their value as distinctive groups, or to aid us in a comparison with the sequence in other localities.

More recently the investigations made during the geological survey of the State of New Jersey have thrown further light upon the order of succession, and the lithological character of the members composing the green sand formation of New Jersey. The section given by Professor Cook, which has been verified by borings in several places, leaves no doubt that we have now arrived at a knowledge of the true relations of the different members of this period as developed in New Jersey; and it is the more interesting since it enables us to show the true position of certain well marked and widely distributed cretaceous fossils, in relation to others which approximate in character to Tertiary types.

The following section gives the expression of all that is at present known regarding the order of succession among the members of the system as they occur in eastern New Jersey.*

		Divisions, lithological characters, etc.	General remarks, sub-divisions, etc.	Characteristic fossils, etc.
	VIII	Green sand, 3d or upper bed.	This bed admits of a triple division, the central portion is nearly destitute of fossils, while those of the upper and lower divisions are mostly dissimilar.	
	VII	Quartzose sand, resembling beach sand.	This bed is (so far as known) quite destitute of fossils.	
Equivalent to Nos. 4 and 5 of the Nebraska section.	VI	Green sand, 2d bed.	(*a*) Yellow limestone of Timber creek.......	(*a*) Characterized by *Eschara digitata, Montivaltia (Anthophyllum) atlanticum, Nucleolites crucifer, Ananchytes cinctus, A. fimbriatus,* Morton.
			(*b*) A bed of nearly unchanged shells........	(*b*) Among the characteristic fossils of this bed are *Gryphæa vomer, G. convexa,* and *Terebratula Harlani.*
			(*c*) Green sand, etc........................	(*c*) *Cucullea vulgaris* is the most characteristic fossil of the lower division.
	V	Quartzose sand, highly ferruginous throughout, and argillaceous in its upper part.	This rock is sometimes indurated or cemented by oxide of iron.	*Excgyra costata, Ostrea larva, Bellemnitella mucronata, Pecten (Neithea) quinquecostatus?* and many other fossils, mostly in the condition of casts of the interior, or impressions of the exterior.
	IV	Green sand, 1st or lower bed.	Several subdivisions may be recognized, depending on the character of the marl, etc.	*Exogyra costata, Orstrea larva, Bellemnitella mucronata, Terebratula Sayi,* (*Gryphæa convexa* and *G. mutabilis*) *Ostrea vesicularis.*
	III	Dark colored clay, containing green sand in irregular stripes and spots.		*Ammonites Delawarensis, Ammonites placenta, A. conradi, Baculites ovatus,* casts of *Cardium.*
			Position of beds Nos. 2 and 3 of the Nebraska section.	
	II	Dark colored clay.......	At the present time the evidence tends to show that No. 1 of the Nebraska section is represented here by Nos. 1 and 2, and that Nos. 2 and 3 of the Nebraska section are wanting, and would find a place between Nos. 2 and 3 of this section, if existing.	This bed contains large quantities of fossil wood, (no animal remains are known to occur in it.)
	I	Fire clay and potters' clay.	....	This bed contains fossil wood and numerous impressions of leaves, but no animal remains.
		Gneiss.		

In Alabama, according to the report of Professor Tuomey, the cretaceous strata admit of a

* This section has been communicated to me by Professor George H. Cook, of the New Jersey Geological Survey, and gives some additional information beyond that already published in his Geological Report.

three-fold division, in which the upper member consists of the "rotten limestone," the central an arenaceous group, and a lower dark colored clay.

Without at present having the means of exact comparison, it may be inferred that there is a close agreement between the different members of the series in Alabama and New Jersey. The specific identity of many of the characteristic fossils leaves no doubt as to the close similarity of the formation there developed, with the beds in New Jersey, from which a large part of the fossils described by Dr. Morton were obtained. The calcareous part of the formation in Alabama acquires a far greater development than in New Jersey, and appears to be there the principal repository of the fossils of this period.

It is now more than fifty years since Messrs. Lewis and Clark, in their expedition to the Columbia river, brought from the Great Bend of the Missouri river some fossils, which were afterwards identified by Dr. Morton as belonging to the cretaceous formation, and from beds of the same age as the marl or ferruginous sand of New Jersey, Delaware, and Alabama. Subsequently Mr. Nuttall brought some species from the same locality. Dr. Morton, in his Synopsis, (1834,) acknowledges the receipt of *Gryphœa Pitcheri* and other cretaceous fossils of great interest, from the plains of Kiamesha, in Arkansas, from Dr. Z. Pitcher, of the United States army. Dr. Morton also mentions other fossils from the falls of Verdigris river, in the same Territory.

It is nearly twenty years since Mr. Nicollet first visited and explored the country about the sources of the Mississippi and some parts of the Missouri river, as far up as Fort Pierre. The collections made by this gentleman enabled Dr. Morton to designate about sixteen species of cretaceous fossils, half of which were regarded as common to that region, New Jersey, and Alabama. Mr. Nicollet, in his report, has given the following section of the beds of the cretaceous formation upon the Upper Missouri:

D.—A plastic clay deposit, about 200 feet thick, divided into two equal parts by a stratum of carbonate of lime in nodules.

C.—A ferruginous clay, of a yellowish color, containing masses resembling septaria and seams of selenite.

B.—A calcareous marl, generally from 30 to 40 feet thick.

A.—"Argillaceous limestone, containing *Inoceramus Barabini* (?) in great numbers, and very much compressed, and so arranged as to give the rock a slaty appearance."*—(At Dixon's Bluff.)

The importance of these divisions does not appear to have been fully appreciated, or the collection was not sufficient to establish the restriction of species within the limits thus indicated.

In the meantime, the explorations of Lieutenant Frémont, of Lieutenant Abert, of Captain Stansbury, and others, and more extended examinations made under the direction of Dr. D. D. Owen, in his Geological Survey of the Chippewa Land District, have brought to light other cretaceous species from this region;† while the several Pacific railroad surveys have shown the occurrence of cretaceous fossils at various points farther to the south, and at intervals which indicate a continuation of the formation from the Missouri river to New Mexico. More recently, Dr. Evans, who had previously visited this region as assistant in the geological survey of Dr.

* The species of Inoceramus in Mr. Nicollet's collection, in a condition here described, was subsequently identified by me as the same with that brought by Captain Frémont from the Smoky Hill river.—(See report, p. 310.)

† In his report Dr. Owen does not notice the subdivisions of Mr. Nicollet's section; and the cretaceous species figured and described appear all to have been derived from a single bed of the formation.

Owen, has collected, and with Dr. B. F. Shumard, has described, several new cretaceous species from the same region.

In 1853, Messrs. F. B. Meek and F. V. Hayden made an extensive collection of the fossils of the cretaceous formation upon the Missouri river in Nebraska; and among these somewhat more than thirty new species, a number equal to all the cretaceous species before known as occurring in that region. These species were described by the writer, in connexion with Mr. Meek, in the Memoirs of the American Academy of Arts and Sciences.* A section of the cretaceous and tertiary strata of the Missouri river and the Mauvaises Terres, compiled from the notes of Mr. Meek, made upon the ground and verified by subsequent examination of the fossils, likewise accompanied the paper just noticed, on page 405 of the same volume.

The order of succession among the beds constituting the cretaceous formation, and their lithological character there established, are as follows:

Section of the members of the cretaceous formation, as observed on the Missouri and thence westward, including the tertiary beds of the Mauvaises Terres.

Tertiary formation			Indurated clays, beds of sandstone, conglomerate, limestone, &c., containing remains of Mammalia and Chelonia, with a few species of fresh water shells.
Cretaceous formation of Nebraska.	Equivalent of Nos. III, IV, V, and VI of the New Jersey section.	C and D of Nicollet's section.	V.—Arenaceous clay, passing into argillo-calcareous sandstone; 80 feet thick. IV.—Plastic clay, with calcareous concretions, containing numerous fossils; 250 to 300 feet thick. (This is the principal fossiliferous bed of the cretaceous formation upon the upper Missouri.)
		A and B of Nicollet's section.	III.—Calcareous marl, containing *Ostrea congesta*, *Inoceramus problematicus*,† scales of fishes, &c.; 100 to 150 feet thick. II.—Clay containing few fossils; 80 feet thick.
			I.—Sandstone and clay; 90 feet. The probable equivalent of Nos. I and II of the New Jersey section.
Carboniferous formation			I.—The sandstone, No. I of section, rests upon buff colored magnesian limestone of the upper carboniferous period.

In this section Nos. II and III correspond to A and B of Mr. Nicollet's section, while the sandstone, No. I, was either overlooked by him, or may have been referred to the carboniferous strata.‡

The divisions C and D of Mr. Nicollet's sections are subdivisions of Nos. IV and V of our section, or probably of No. IV alone, since No. V is not known to occur on that part of the

* "Description of New Species of Fossils from the Cretaceous Formation, by James Hall and F. B. Meek. Memoirs of the American Academy of Arts and Sciences, vol. V, new series.

† In a subsequent exploration of this region Dr. Hayden discovered *Inoceramus problematicus* in this bed, in precisely the same conditions and in a rock identical with that in which the specimens occur brought by Captain Frémont from the Smoky Hill river, and by Captain Stansbury from between the Big and Little Blue rivers.

A careful comparison of *Inoceramus fragilis*, from bed No. 2, Nebraska section, (Hall and Meek, Memoirs Amer. Acad., vol. V, new series, page 388,) has satisfied both Mr. Meek and myself that it is identical with *I. problematicus*, the specimen described being the young of that species. The young specimens of the latter shell from Arkansas and Smoky Hill river present no essential differences from those of Nebraska.

Dr. Hayden has likewise made extensive collections in other parts of the Nebraska cretaceous and tertiary formations during the past two years. The new species of these collections have been described by Messrs. Meek and Hayden, in several papers published in the proceedings of the Academy of Natural Sciences of Philadelphia. These explorations, with the extensive collections of fossils, have served to sustain the correctness of the order of succession among the subordinate members of the series as given in the section above; indicating, however, that the beds Nos. II and III, as well as Nos. IV and V, may in some localities merge into each other; while the limits between Nos. III and IV remain well marked throughout the region explored.

‡ From the fact that Mr. Nicollet remarks, (page 35,) that the part of stratum A above water, on the day of his "examination, was three feet," we may infer that the sandstone No. I was not seen by him.

Missouri which was examined by Mr. Nicollet. Although admitting of several subdivisions from changes in lithological character, the beds of No. IV do not present any groups of fossil species restricted within the physical or lithological limits designated, and they can scarcely, therefore, be regarded as of importance in the classification of the formation, or valuable in tracing the limits of its members over a wide extent of country.

The subdivisions A and B, corresponding to Nos. II and III of our section, are more important; and, although yielding so few fossils on the Missouri, they become well marked in other parts of the country. The "*Inoceramus Barabini*," represented by Mr. Nicollet as found in great numbers at Dixon's Bluff, very much compressed and so arranged as to give the rock "a slaty structure," is undoubtedly the *Inoceramus problematicus*, which is known to occur in this position, and does not occur in the higher beds of the formation upon the Missouri, so far as known at the present time. The *Ostrea congesta*, and all the other fossils from beds Nos. II and III of the section, are unlike species from New Jersey or Alabama, and appear to be restricted to these beds. At the same time the species identical with or analogous to species of New Jersey and Alabama occur in beds Nos. IV and V, which may perhaps be regarded as subdivisions of one group.

We are warranted, therefore, in referring the beds above No. III to the fossiliferous beds of New Jersey and Alabama, while we have yet no evidence that Nos. II and III do occur in either of these States.

The beds Nos. III, IV, V, and VI of the New Jersey section, given on a preceding page, correspond in their fossils with Nos. IV and V of the Nebraska section; leaving the third green sand of New Jersey (No. VIII of that section) unrepresented in the northwest, so far as known at the present time.

The New Jersey beds, Nos. I and II, which are marked only by fossil wood and impressions of leaves, appear to be represented by No. I of the Nebraska section, judging from the general character of the remains yet known in the two. Should this inference prove to be correct, the beds Nos. II and III of the Nebraska section will hold a position between Nos. II and III of the New Jersey section; but I do not regard this question as yet determined.

The relations of the beds Nos. II and III of the Nebraska section, and their characteristic fossils, become very important when we undertake the comparison of the cretaceous formation of Texas and New Mexico with that of Nebraska, Alabama, and New Jersey.

The wide extent and persistence of *Inoceramus problematicus*, and its restriction to beds Nos. 2 and 3, and their equivalents, so far as at present known, render it of great value in determining a geological horizon. This species was first brought from the Missouri river by Mr. Nicollet.* It was collected by Captain, now Colonel, Frémont† upon the Smoky Hill Fork, where it occurs in a gray or buff color, and also in a blue, slaty limestone in great numbers, and being extremely flattened, gives to the rock a slaty structure, as described by Mr. Nicollet.

* Report on the Upper Mississippi River, by J. N. Nicollet, 1853.

† Report of the Exploring Expedition to the Rocky Mountains, by Captain J. C. Frémont, 1854. Appendix, geological formations and organic remains, by James Hall. At the time of my examination of Captain Frémont's collections, I had an opportunity of comparing the specimens of *Inoceramus* with those brought from the Missouri by Mr. Nicollet, and identified the specimens in the two collections as the same species. The collections of Mr. Nicollet were, at that time, broken up, and I saw some of them in Professor Ducatel's possession, in Baltimore, and others in Georgetown. The information given me was, that they were from near the Great Bend of the Missouri; but by the examination of Mr. Nicollet's report, it is very clear, from his statements, page 35, that this *Inoceramus* occurs at Dixon's Bluff, and not at Great Bend, since Mr. Nicollet refers to the former locality as exhibiting the base of the formation.

The specimens collected by Lieutenant Abert,* at Poblazon, are doubtless of this species, and are referred by Professor Bailey to the same species as those of Frémont's report. The same species was brought by Captain Stansbury † from between the Big and Little Blue rivers, in precisely the same conditions, and in a similar rock. In 1854 I received specimens of the same fossil, collected at several points on the Arkansas, by Colonel Frémont, during his later expedition. These occur in part in a bluish, or dull lead-colored, argillaceous limestone, and others in a gray or buff-colored limestone.

Dr. Schiell collected this species of *Inoceramus* at the bend of the Arkansas river; and it is mentioned by Dr. Roemer as occurring near New Braunfels, in Texas. Dr. F. V. Hayden has, more recently, brought the same from the bed No. 3, Nebraska.

In Arkansas, this fossil is collected from the same localities, and apparently in the same position from which are obtained numerous species of *Echinoderms*, *Gryphæa Pitcheri*, and other fossils of species yet unknown in Nebraska, or in any localities east of the Mississippi river.

Fragments of the same species of *Inoceramus* occur in an argillaceous limestone, among the collections of the Boundary Survey, from the basin of the Rio Grande. In the same connexion occur several *Echinoderms* of species identical with those from Arkansas—*Gryphæa Pitcheri*, *Ammonites Texanus*, etc.

The collections of the Pacific Railroad Surveys, which have been placed in my hands for examination, show that *Ostrea congesta* was collected by Mr. Marcou, from a point three miles north of Galisteo, between Fort Smith and Santa Fé.‡ This fossil, in Nebraska, is associated with *Inoceramus problematicus*. In the same collection, and from the same locality, near Galisteo, there were specimens of a slaty limestone containing fragments of *Inoceramus*, which, although not identified at the time, is probably the *Inoceramus problematicus*. Thus we have abundant evidence of the distribution of this species from Nebraska to New Mexico.

The section already established for the cretaceous strata upon the Missouri, as given above, and the occurrence of *Inoceramus problematicus* in the beds Nos. 2 and 3 of that section, serve to fix the place of that fossil in the series in reference to the other beds constituting the cretaceous formation in Nebraska. From the analogy of the beds Nos. 4 and 5, and the identity of several important species of fossils with those of New Jersey, Alabama, and Tennessee, we may regard the position of this fossil as determined in reference to the members of the series which occur in these States, this species having never been found, so far as we are aware, in either New Jersey, Alabama, or Tennessee. Thus this fossil becomes one of the best guides for the identification of certain strata in the cretaceous system of the United States.

In a paper recently published in the proceedings of the Academy of Natural Sciences, by Messrs. Meek and Hayden, speaking of the geographical distribution of the cretaceous fossils, they refer to the well known species *Ammonites placenta*, *Scaphites Conradi*, *Baculites ovatus*, and *Nautilus Dekayi*, as being common to the central or upper portions of New Jersey cretaceous strata, to the rotten limestone of Alabama, and to beds Nos. 4 and 5 of Nebraska. Alluding to the position of the cretaceous beds of the southwest, they remark:

"At the same time the total absence of the above named fossils, and, indeed, so far as we yet

* Report on a Geograghical Examination of New Mexico, by Lieutenant J. W. Abert, 1848. Notes concerning the minerals and fossils, by Professor J. W. Bailey, page 547. See note [pp. 117, 118] of the present report.

† Exploration of the Valley of the Great Salt Lake, by Captain Howard Stansbury, 1852. Appendix, geology and palæontology, by James Hall; page 402.

‡ See Pacific Railroad Reports; survey of the thirty-second parallel; Chapter IX, page 102.

know, of all the other species of the lowest and upper two Nebraska Cretaceous formations in the rocks from which Roemer and others collected so many species in Texas, and other southwestern localities, renders it highly probable that if the latter occur at all in Nebraska, they must be represented by the beds Nos. 2 and 3 of our section. This conclusion is further strengthened by the fact that the only Nebraska species yet found in the southwest, so far as we know, are *Inoceramus problematicus* and *Ostrea congesta*, both of which are unknown in the northwest, excepting in the above named beds, and are mainly restricted to the latter. The well marked specific characters of these two fossils and their limited vertical range, together with their extensive geographical distribution, render the bed in which they occur a horizon as the highest importance in the identification of strata at remotely separated localities in these far western Territories.

"That these beds, or formations of the same age, are widely distributed over a vast area of country, extending from near the great bend of the Missouri, in latitude 44° 15′, longitude 99° 20′, westward to, and perhaps beyond, the eastern slope of the Rocky Mountains, and far south into Texas and New Mexico, is highly probable, from the occurrence of their characteristic fossils at many widely separated localities in this region. At any rate we know, from information obtained through Mr. Henry Pratten, of the geological survey of Illinois, that *Inoceramus problematicus* is found in a light-colored limestone overlying a red sandstone on Little Blue river, a tributary of Kansas river. Colonel Frémont also collected specimens of the same shell from a similar rock on Smoky Hill river, in latitude 39°, longitude 98°, and at other localities between there and the rocky mountains.* More recently Lieut. Abert found the same, or a closely allied species, at a point as far southwest as latitude 35° 3′ N., longitude 107° 2′ W., and apparently on the western declivity of the anticlinal axis of the Rocky Mountains.† Roemer likewise collected in Texas specimens of a shell he refers to *Inoceramus mytiloides* of Mantell, which is considered identical with *I. problematicus* of Schlotheim. In addition to this we have seen, in Mr. Marcou's collection, specimens of *Ostrea congesta*, from Galisteo, between Fort Smith and Santa Fé, where it probably holds the same geological position as the so-called *Gryphœa dilatata*.

"The formations from which the above named fossils were obtained in the southwestern Territories, appear, from the statements of the various explorers of that region, to repose on a series of red, yellow, and whitish sandstones, and various colored clays, which are referred by Mr. Marcou to the Jurassic and Triassic systems. These lower beds, we think, are represented wholly or in part in Nebraska, by our formation No. 1, which, as previously stated, we regard as probably belonging to the lower part of the Cretaceous system, though it may be older."

Finally, in reference to the relative position in the series of a large part of the cretaceous fossils of the Boundary Survey, I have already, in a previous communication, stated that I regard them as occurring in the same geological horizon with the beds of Smoky Hill river, Poblazon, &c. I am now prepared to fix their position in the same parallel with beds Nos. 2 and 3 of the Nebraska section, and below those beds in New Jersey and Alabama, which contain *Baculites ovatus*, *Nautilus De Kayi*, and *Ammonites placenta*.

The reasons for this conclusion are obvious from what has preceded. The most conspicuous known fossils of beds 2 and 3 in Nebraska, are found in Arkansas and elsewhere, associated

* See Prof. Hall's figures and remarks in Frémont's report, p. 174, pl. 4.

† Lieut. Abert's report of explorations in New Mexico and California, p. 547.

with many of the species of the Boundary Survey collections, and from the persistence of *Inoceramus problematicus*, and the almost uniform character of the rock in which it occurs, from Nebraska to New Mexico, we can have no doubt that the beds containing this fossil everywhere occupy the same horizon.

The collections from the southwest have never furnished specimens of the cephalopods enumerated above, which characterize the upper cretaceous strata, and the few fossils which are common to Texas and New Mexico and New Jersey, render it probable that the higher beds of the formation have thinned out in that direction to a degree which renders them subordinate in importance to the lower beds of the system. The few specimens identical with species known in New Jersey, Alabama, and Tennessee, appear, from their color and the character of the associated rock, to have been obtained in a different bed from that of the greater number of specimens in the collection, which are associated with a more calcareous rock. At the same time, the absence of sections of strata leaves us without positive information in this respect.*

In the present state of our knowledge, it would appear that the beds 2 and 3 of the cretaceous formation of Nebraska have gradually increased in thickness and importance in a southwesterly direction, and, at the same time, have become more fossiliferous. In tracing the same beds through Arkansas, we find, in addition to the *Inoceramus problematicus*, and associated with that fossil, *Holectypus planatus*, *Toxaster elegans*, *Holaster simplex*, *Cardium multistriatum*, *Inoceramus confertim-annulatus*, *Gryphœa Pitcheri*, and others, which occur also among the Boundary collections. These facts clearly show that the beds have become much more fossiliferous than on the Missouri, or on the Kansas and Blue rivers, and we must regard the greater part of the Boundary collections as derived from the horizon of these beds.

From the great vertical range of the characteristic cephalopods, above enumerated, in New Jersey, and their wide geographical distribution, and from the marked distinction in the types of fossils holding the lower position, we shall probably find it convenient to subdivide the cretaceous formation into three great groups:

3. The upper division, comprising the first and second marl beds of New Jersey, with the intermediate ferruginous sand, and the clay below the first greensand bed, (Nos. III to VI of the section,) parallel to the beds 4 and 5 of Nebraska.

2. The middle division, equivalent to the beds 2 and 3 of Nebraska, and the calcareous beds of the southwest, Arkansas, Texas, and New Mexico, containing the numerous *Echinoderms*, *Inoceramus problematicus*, *Gryphœa Pitcheri*, *Hippurites*, *Caprina*, *Nerinea*, *Ammonites Texanus*, and numerous other fossils.

1. The lower division, represented by No. 1 of Nebraska, and probably equivalent to the lower clay beds of New Jersey, in which the only fossils yet known are of vegetable origin.

It is not unlikely that the medial division may prove, in many localities, to be divisible into distinct beds beyond those recognized in Nebraska; or, that as the formation expands to the southward, other beds not known on the Missouri will come in, or that the two there known will be found to become much modified in character.

* A single observation in the notes accompanying the specimens leads me to infer that *Exogyra costata*, and one or two species besides, were collected from a higher position in the cliff than the other fossils. Since, however, it is probable that many species, not known in the same association in New Jersey and Alabama, may occur in connexion with *Exogyra costata* in the southwest, we cannot at this time separate the species belonging to the upper and lower divisions of the formation.

I learn, also, from Dr. Parry, since these pages were written, that he regards the bed containing *Exogyra costata* and some other species, as holding a higher position than the calcareous beds of Leon Springs, and other localities along the route.

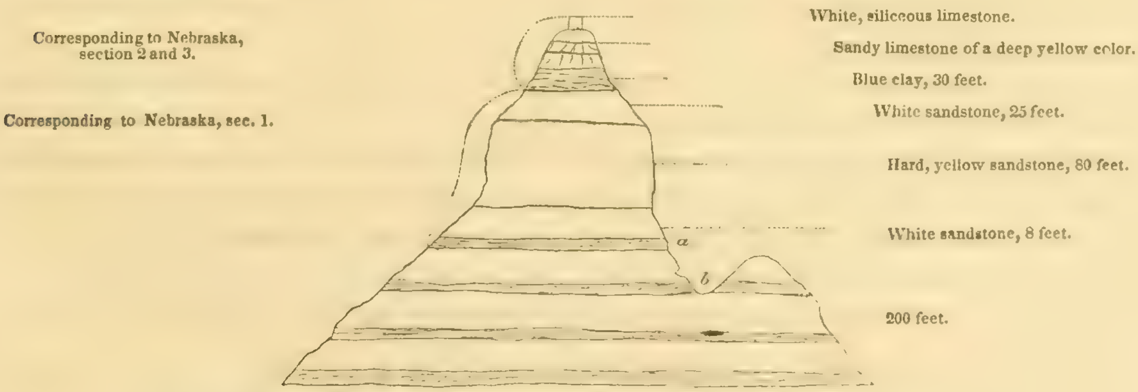
From the facts before us it appears that Nos. 4 and 5 of the upper division, which are so largely developed on the upper Missouri, become gradually attenuated towards the southwest, and lose in a great measure their distinctive fossils.

Although the specimens in the boundary collections do not clearly indicate the occurrence in that region of the sandstone No. 1 of the Nebraska section, it is nevertheless quite certain, from other collections in my possession, that the same rock occurs on the Arkansas river, possessing the same characters as in Nebraska.

Dr. Shumard, in his examinations in Arkansas, speaks of a sandstone which clearly holds the place of No. 1 of our section. On page 181 of report, before cited, he says: "Passing this range, the sandstone again reappears, and constitutes the prevailing rock to within a short distance of Fort Washita, where it disappears, and is succeeded by strata of the cretaceous period." Although not recognized by Dr. Shumard as a member of the cretaceous formation, still it holds, in regard to the beds in Arkansas, equivalent to Nos. 2 and 3 of Nebraska, the same relative position as the sandstone No. 1 on the Missouri river.*

The observations made in the course of the boundary survey, and in all the other surveys in the southwest, show the occurrence of various colored sandstones and clays below the fossiliferous beds identified, as above, with Nos. 2 and 3 of the Nebraska section. Indeed, we have evidence, from numerous observations, of the occurrence of a similar sandstone at so many points from Missouri to New Mexico as to render it certain that the formation is continuous over this wide extent of country.

The observations of Mr. Marcou, on the line traversed by one of the Pacific railroad surveys, induced him to regard these sandstone as of older date than the cretaceous formation. In a section of Pyramid Mountain given by Mr. Marcou, (*Bulleten Soc. Geol. de France, tome* 12, *p.* 878,) he recognizes a series of sandstones and clays beneath limestones which are of unquestionable cretaceous age.



"*a*. Bed of variegated marls in contact with the Jurassic formation."
"*b*. Alternations of calcareo-argillaceous marls of variegated colors—red, green, and white."
"*c*. Bed of *Gryphæa dilatata* and of *Ostrea Marshii*."†

* I believe that Dr. B. F. Shumard regards this sandstone, in part, or altogether, as of carboniferous age; but it is difficult to understand these relative positions, since in numerous localities, from the Missouri river to Texas, the upper carboniferous limestone is the highest determined carboniferous rock, and underlies the sandstone No. 1 of the Nebraska section.

† These explanations of the section quoted above are those given by Mr. Marcou. The designations at the right hand are those given by him in the text accompanying the section.

Having examined the specimens in Mr. Marcou's collection from this locality, I have no hesitation in saying that the specimens labelled by him as *Gryphœa Tucumcarii* (*G. dilatata*, var. *Tucumcarii*, *Bul. Soc. Geol. de France, tome* 12, *pl.* 21) are the *Gryphœa Pitcheri* of Morton, and present no features, either in form, characters, condition of preservation, or otherwise, which can serve to distinguish them from *Gryphœa Pitcheri*, in the boundary survey collections, from strata forming a continuation of the Llano Estacado.*

In the section of Pyramid Mountain given by Mr. Marcou, the exhibition of the sandstones and clays beneath the limestone, with *Gryphœa Pitcheri*, is extremely interesting, as giving the succession of beds, with lithological character, more in detail than has elsewhere been published from that region.

For the purpose of comparison, I subjoin some detailed sections made by Mr. Meek, in 1853, upon the upper Missouri, and which are collectively merged in the sandstone No. 1 of our section of the cretaceous formations, as already given.

Section at the mouth of Big Sioux river.

Partially indurated, silicious clay, or marl, of a slightly yellow color, and showing scarcely any lines of stratification. Slope of 60 feet of modern or bluff formation.

Part of No. 1, *section of Nebraska cretaceous formation.*

1. Soft, yellow sandstone, with vertical veins and joints filled with silicious oxide of iron; also, hard, horizontal seams, containing much iron, with casts of *Pectunculus Siouxensis:* 10 feet.

2. Large, concretionary masses, 8 to 10 feet long, and 6 feet thick, consisting of hard, fine-grained sandstone, with perhaps some calcareous matter, laminated on the weathered surfaces: 6 feet.

3. Soft sandstone, like that above, with horizontally arranged concretions of siliceous oxide of iron, which are often hollow.

The three lower divisions of sandstone constitute the upper part of No. 1 of the Nebraska section. They were not seen in actual contact with beds of No. 2; but, from their position and dip relative to the other beds, there can be no doubt of the relations of the two. Subsequently, Dr. Hayden has seen the beds of Nos. 1 and 2 in actual contact on the Big Sioux river.

At a point twenty-five miles below Sergeant's Bluff there is an exposure of about 100 feet, consisting of beds of sandstone and clay, which present great irregularity in bedding, some of the strata rapidly expanding in one direction, while others thin out in the opposite direction.

Section on the right-hand side of the Missouri river, twenty-five miles below Sergeant's Bluff.—Successive beds, or strata, forming part of No. 1, *Nebraska section of cretaceous formation.*

1. A bed of dark-gray clay, alternating above and below with soft sandstone seams. The middle mostly clay; 6 feet.

2. Light, yellow clay, passing downwards into a very soft, gray sandstone; 5 feet.

3. Very dark clay, with fragments of carbonized wood; 1½ feet.

* The specimens from Pyramid Mountain are figured in the Report of the survey of the 35th parallel, and those of the boundary survey will be found in the present volume.

4. Gray, indurated clay, or marl, with pieces of carbonized wood ; 4 feet.

5. Dark seam, like No. 3 ; 8 inches.

6. Clay, like No. 4 ; 3 feet.

7. Gray sandstone, with fragments of carbonized wood ; 2 feet.

8. Very dark gray clay, sometimes black, and containing much organic matter in the lower part, crystals of selenite, etc. ; 10 feet.

9. Gray clay, with many fragments of carbonized wood ; harder concretions of the same clay, containing carbonized wood ; 30 feet.

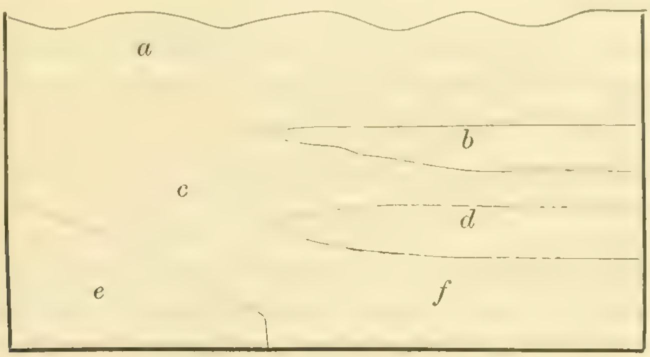
10. Gray sandstone, with pieces of carbonized wood ; 2 feet.

11. Gray clay, with thin, wedge-shaped masses of hard bituminous coal, or lignite, and round lumps of sulphuret of iron.

Slope to river-level 30 or 40 feet, in which no beds, in place, were seen.

Many of the beds noted in the above section are seen to thin out entirely, or wholly to change their character in the same bluff within a distance of not more than fifty yards ; while others, so thin and obscure as to attract no attention, are seen to increase to a much greater thickness in a very short space ; while about two hundred yards below where the above section was made, the same line of bluff passes wholly into a soft, heavy-bedded sandstone, which breaks into large, columnar masses from the top to the base of the cliff.

The following sketch gives an example of the irregularity of the stratification in these bluffs of sandstone and clay :



a. Soft, heavy-bedded, yellow sandstone, with pieces of carbonized wood.
b. Dark, almost black, slaty clay, with much carbonized matter.
c. Gray sandstone, with specks of carbonized wood
d. Hard, reddish sandstone.
e. Indurated gray clay, weathering to a light reddish hue.
f. Sandstone like the upper bed.

These are exhibitions of isolated exposures of the sandstone, clay, etc., constituting No. 1 of the Nebraska section, and which, from its relative position to certain fossiliferous beds, underlies the calcareous strata containing *Gryphœa Pitcheri*, and its associated fossils. This sandstone (No. 1) will include, at least, all that portion of the Pyramid mountain on the left hand side, marked in the diagram 1, while the blue clay, sandy limestone, and white, silicious limestone, represent, as we believe, the beds Nos. 2 and 3 of Nebraska ; and this inference is deduced from the facts already stated, that these calcareous beds of the Llano do elsewhere contain the association of fossils characteristic of the horizon of Nos. 2 and 3, which we clearly trace from Nebraska to New Mexico, and which are likewise, over a large part, or the whole distance, underlaid by sandstones, etc.

With regard to the two hundred feet of sandstones and clays below *a* of the Pyramid mountain, these may be a distinct formation, or they may be a part of the same formation as the beds above. Of all the collections yet examined from the southwest, not a single fossil from beds below those containing *Gryphœa Pitcheri*, and its associated fossils, has come under my notice. We are, therefore, without the means of identification at the present time.

The sandstones of the northwest have a great development, and it is not probable that we yet know their full thickness or their relations throughout. The collections made by Dr. Hayden, at the mouth of the Judith river,* contain a single genus, *Hettangia,* which, in Europe, is considered as restricted to the Liassic epoch. This, however, is associated with cretaceous types, and though there is some evidence in favor of a reference to the Jurassic period, we have not satisfactory proof.

The results at which we have arrived in regard to the identity of the western and southwestern cretaceous formations, may be more clearly appreciated by a comparison of sections of the upper Missouri and of the same formations on the line of the Boundary Survey.

Section of the Llano Estacado and the prolongation of the same beds to the southwest.

4. Tertiary sandstone, conglomerates, etc., with clays and impure limestones.

3. Dark colored, argillaceous limestone, frequently composed largely of broken shells, and containing *Exogyra costata.*

2. Yellow, or buff colored limestone, arenaceous limestone, clays, etc., with *Inoceramus problematicus, Gryphœa Pitcheri, Ammonites Texanus, Toxaster Texanum, Pyrina Parryi,* etc.

1. Sandstones and clays of a white, gray, or red color, containing few or no fossils.

Section of the beds seen on the Missouri river from Dixon's Bluff to Fort Pierre, and thence to Mauvaises Terres.

4. Tertiary sandstones, conglomerates, argillaceous limestone, clay, etc.

3. Light colored calcareous clay, and dark colored astringent clay, with nodules of limestone.

2. Gray or buff colored, and blue or lead colored argillaceous limestone, clay, etc., containing *Inoceramus problematicus, Ammonites,* etc.

1. Sandstones and clay, white, gray, or brown, in irregular and unequal alternating beds, containing few fossils beyond fragments of carbonized wood.

I can, therefore, only regard the sandstone of the southwest, or at least a large part of it, as identical in age and a prolongation of the formation No. 1 of Nebraska, and which, from the evidence of its cretaceous character and the absence of any evidence to the contrary, I refer to the cretaceous period.

* The formation at the mouth of the Judith river, containing a group of fossils quite distinct from any heretofore described, has been referred by Messrs. Meek and Hayden, provisionally, to No. 1 of the Nebraska section, from its general lithological analogy, and from position ; but at that point the beds 2 and 3 are wanting, these fossiliferous beds lying immediately below No. 4 of the section.

REMARKS UPON THE TERTIARY FORMATION.

In addition to the Eocene marine tertiary fossils of the Boundary collections, there are numerous specimens of regularly stratified sandstone, conglomerate, clay, etc., which are referrible to the tertiary period. The relations of the beds of these different series and their great thickness indicate that they belong to a system of deposits having a wide extent in that part of the country from which the specimens were derived. The mineral aspect of the specimens, the association of clays, sandstones, and conglomerates, show a close similarity with the tertiary formation of the Mauvaises Terres of Nebraska. Further explorations, collections, and comparisons are certainly necessary before this identity can be fully established; but the numerous intermediate explorations, from the Missouri river to the Mexican boundary line, indicate the occurrence of similar formations along the entire distance. The collections from the tertiary basin east of the Cordilleras likewise present specimens of lithological aspect and conditions so similar to those of the Rio Grande on the east, that there would appear to be some relation between the formations at these distant points.

The tertiary materials in the collections do not appear to me sufficient to furnish more than grounds for a probable inference regarding the identity of the formations, and in the almost entire absence of fossils from the western basin, it might be unwise to express any positive opinion regarding the equivalency of these beds.

Without possessing the means of a detailed section of the successive beds along the line of the boundary survey, we are able, from the specimens of rocks and fossils in the collection, to present the order of succession and general features of the formations and their relative position.

The following section will serve to show the order of succession and relative age of the formations crossed by the Boundary survey:

TERTIARY FORMATION.

Tertiary formations on the west coast, probably of Miocene age.

Tertiary formations east of the Cordilleras, consisting of beds of sandstone, sand,* conglomerates, etc., with subordinate beds of sandstone. Formations in the valley of the Rio Grande, consisting of sandstone and conglomerate, with their calcareous beds, resembling in many respects the tertiary formations of the Mauvaises Terres in Nebraska.

Calcareous beds, with marine fossils of the Eocene tertiary, apparently underlying unconformably the preceding strata.

CRETACEOUS FORMATION.

Argillaceous beds, containing *Exogyra costata*, etc.

Calcareous beds of a buff color, and similar beds of a lead color, with beds of white limestone, containing *Gryphæa Pitcheri*, *Cardium multistriatum*, *Toxaster*, *Holectypus*, *Cyphosoma*, *Pyrina*, *Ammonites Texanus*, *Hippurites*, *Caprina*, *Nerinea*, etc.

Sandstone of various colors, white, brown, red, etc., with beds of clay, etc.

CARBONIFEROUS FORMATION.

Upper carboniferous limestone, containing *Spirifer cameratus*, *S. lineatus*, *Terebratula subtilita*, and other fossils of the age of the coal measures. Perhaps, also, some other members of the coal measures, represented in the altered sandstones and slates of the collection.

* The drifting sands of the southwest, like those of the north, appear to be derived from the sandstones of the tertiary period

DEVONIAN AND SILURIAN FORMATIONS.

The specimens referrible to strata of this age are few, and these are in such condition as to give little satisfactory information regarding the rocks in place.

NEWER IGNEOUS AND METAMORPHIC ROCKS.

Igneous and metamorphic rocks of the Limpia, Guadaloupe, and Organ mountains, Sierra Madre, etc., which are of modern origin.*

OLDER METAMORPHIC ROCKS.

Metamorphic rocks of Silurian and Devonian age, forming the range of the Cordilleras and the isolated mountains in the great plain on the east of that mountain chain.

* The materials which appear as the result of igneous and metamorphic action, may be derived from rocks of the coal measures and from older formations, as well as from those of more recent date. But from all we know of the character of metamorphic, silurian, devonian, and carboniferous strata elsewhere, those here referred to do not possess the same characters and do not belong to the same period of metamorphism.

DESCRIPTIONS OF CRETACEOUS AND TERTIARY FOSSILS.

BY T. A. CONRAD.

The organic remains in the collection of the Boundary Survey are chiefly cretaceous shells, which I have carefully compared with the Alabama and New Jersey species; and out of more than one hundred species in Roemer's and the Survey collections, I can find only two that may be considered identical with New Jersey species. These are *Exogyra costata* and the *Ostrea vesicularis* of Lam., which is at least a marked variety, termed *ancella* by Roemer. D'Orbigny places some of Roemer's Texan species in the same division to which he refers all the New Jersey species, the Senonian stage; yet I think there is sufficient evidence that the cretaceous strata of Texas are not exactly synchronous with those of New Jersey, or of Alabama, while those of the latter State appear to form a passage or intermediate stage between the cretaceous strata of the two former states, which, besides the *Exogyra* and *Ostrea* above mentioned, have four other species in common, viz: *Gryphæa Pitcheri*, *Trigonia thoracica*, Morton, *Baculites anceps*, and *B. asper*.

Among these interesting fossils, those from Leon Springs are conspicuous for variety and beauty, and unequivocally mark the cretaceous period. There is not the slightest trace of the Jurassic or any formation older than the grand epoch of the chalk. A few interesting fossils from near the mouth of Puercos river are imbedded in a white, chalky limestone, and, with the exception of *Ammonites Texanus*, are peculiar to this locality, in the present state of our collections. There is a specimen of flint from Leon Springs of the horn-shaped form so common in the chalk of Europe.

A few Eocene shells collected by Mr. Schott, of the age of the Claiborne formation, prove that Eocene strata occur in western Texas.

Eocene species.

Cardita planicosta, Arroyo Las Minas, between Eagle Pass and Leon.
Corbula nasuta, Con.
Cytherea Nuttalli, Con.
Cassidula alveata, Con.
Volutilithes Sayana, Con.
Natica limula, Con.

Cretaceous fossils from Oak Creek, Texas, collected by Arthur Schott.

Ammonites Texanus, Roemer, near Puercos river.
Nerinea Schotti, Con., near the mouth of Puercos river.
Caprina occidentalis, Con., near the mouth of Puercos river.
C. planata, Con., Oak creek, near Puercos river.
Hippurites? n. s., near the mouth of Puercos river.

Cretaceous fossils from between Rio San Pedro and Rio Puercos, collected by A. Schott.

Rostellaria? collina, Con.
R.? Texana, Con.
Natica collina, Con.
N. Texana, Con.
Buccinopsis Parryi, Con.

Cretaceous fossils from between El Paso and Frontera, collected by Colonel W. H. Emory.

Exogyra Matheroniana, D'Orbigny.
Gryphæa Pitcheri, Morton.
Cardium (Protocardia) Texanum, Con.
Trigonia Emoryi, Con.
Neithea Texana, (*Pecten*, Roemer.)
N. occidentalis, Con., (*quadricostata*, Roemer.)
Plicatula incongrua, Con.
Arca subelongata, Con.

Cretaceous fossils from Leon Springs, collected by Colonel W. H. Emory.

Exogyra Matheroniana, D'Orbigny.
E. arietina, Roemer.
E. læviusscula, Roemer.
Gryphæa Pitcheri, Morton.
Trigonia Texana, Con.
Lima Leonensis, Con.
Neithea filosa, Con.
N. Texana (*Pecten*, Roemer.)
N. occidentalis, Con.
Cardium multistriatum, Shumard.
Arcopagia Texana, Roemer.
Cardium Sancti-sabæ, Roemer.
Capsa Texana, Con.
Terebratula Choctawensis, Shumard.
Caprina crassifibra, Shumard.
Turritella Leonensis, Con.
Natica, ———.
Hamites larvatus, Con.
Ammonites flaccidicosta, Roemer.
A. Texanus, var. Roemer.
Cyphosoma Texanum, Roemer.
Pyrina Parryi, Hall.
Holectypus planatus, Roemer.
Toxaster Texanum.
Turbinolia Texana, Con.

Cretaceous fossils from Jacun, 3 miles below Laredo, collected by A. Schott.

Inoceramus Crispii, Mantell.
I. Texanus, Con.
Ostrea crenulimargo, Roemer.
Exogyra costata, Say.
Dosinea, (imperfect casts.)
Turritella (casts.)
Natica, (casts.)

Cretaceous fossils from Lepan Hills, collected by A. Schott.

Exogyra arietina, Roemer.
Terebratula Wacoensis, Roemer.
Neithea Texana (*Pecten*, Roemer.)
Cardium congestum, Con.
Ammonites Texanus, Roemer.
Hemiaster Texanus, Roemer.
Holectypus planatus, Roemer.

Of the above species *C. congestum* was collected on the Rio San Pedro, and all the others on the Rio Bravo del Norte.

Cretaceous? fossils from Dry Creek, Mexico, collected by A. Schott.

Ostrea cortex, Con.
O. multilirata, Con.

Cretaceous fossils from various localities, collected by A. Schott.

Neithea Texana (*Pecten* Roemer.) San Pedro River, mouth of painted caves; valley of the Rio Bravo, a few miles below the mouth of Rio San Pedro; upper valve of the same, near the mouth of the San Pedro.

Terebratula Wacoensis, Roemer, Aroyo Pedras Pintas.
Terebratula Wacoensis.—*Ibid.*
Inoceramus Crispii, Mant. Aroyo Pedras Pintas and Las Moras.
" " ? Salt Creek.
Neithea occidentalis, Con. Aroyo Las Minas, between Leon and Eagle Pass.
Ostrea carinata? Lam. Turkey Creek, Las Minas.
O. anomiæformis, Roemer, Turkey Creek, Las Minas.
Cardium congestum, Con. Valley of Royo San Felipe.
Ammonites flaccidicosta, Roemer, bed of Rio San Pedro.
A. Texanas, Roemer.
A. pedernalis, Roemer, Rio Bravo del Norte, near the mouth of Puercos river.
A pedernalis, Yellow stone.
Rostellites Texanus, Con. Eagle Pass.

POLYPI.

TURBINOLIA, Lam.

TURBINOLIA, TEXANA.

PLATE II, FIG. 3, *a*, *b*.

Horn-shaped, curved, with transverse, obtuse undulations; radii equal, prominent, numerous, (about 50 in number,) transverse section oval.

Locality.—Between El Paso and Frontera.

There are two specimens of this fossil in the collection, but the cup in each is filled with a portion of the limestone in which they were imbedded, and the characters are thus concealed.

ECHINODERMATA.

Several species of this family occur among the collections of the Boundary Survey. Three of these are identical with species described by Dr. F. Roemer, in his Kreidebildungen von Texas, while two others are quite distinct. Owing to the imperfection of the specimens in the collection, some of the figures have been copied from the work cited. It was not until the collections of the second survey of the Boundary were received that the *Toxaster elegans* was observed, and it has been figured on the supplementary plate 21. The association of these and other species with the well known cretaceous fossil *Gryphœa Pitcheri*, figured upon the same plate, leaves nothing further to be desired in proof of the age of the formation.*

PYRINA PARRYI, Hall.

PLATE I, FIG. 1, *a–d*.

Shell oblong ovoid, or somewhat pentagonal, with the angles rounded, convex above and concave in the middle beneath; apex central, flat or slightly depressed, prominently convex in front, and subtruncate behind; mouth central, oval; anus ovate, narrower above and situated centrally between the upper and lower side of the shell; ambulacral areas somewhat prominent or slightly elevated above the rest of the surface. Tubercles on the upper side scattered, with granular spaces between, becoming more numerous on the sides and crowded on the base of the shell. Length $1\frac{1}{4}$ inches; width $1\frac{1}{8}$ inches.

The general contour of the fossil is a broad oval, slightly narrower behind and subtruncate; while the elevation of the ambulacral space in front gives it a slight prominence in that part. This prominence of the ambulacral spaces likewise often gives an obtusely pentagonal form to the shell; but this character is not constant, nor is the slight prominence in front observable in all specimens.

This neat and pretty species is readily distinguishable from any other yet described from the cretaceous rocks of the southwest.

* Prof. Agassiz, to whom these fossils were submitted, expressed his opinion that they were from the lower cretaceous formation.

Fig. 1*a*. Upper side of specimen.
Fig. 1*b*. Lower side.
Fig. 1*c*. Posterior view.
Fig. 1*d*. Portion of the summit enlarged.
Locality.—Leon Springs, El Paso road.

TOXASTER TEXANUS.

PLATE I, FIG. 2, *a–c*.

Toxaster Texanus, Roemer, Kreidebildungen von Texas; p. 85, pl. x, fig. 3.

Shell oblong, subpentagonal-ovate, rotund before, the middle emarginate, truncate behind, elevated convex; mouth transverse, subreniform; anal aperture round-oval; the larger tubercles arranged in a triangular area upon the lower surface.

The specimens of this species in the collection are somewhat compressed vertically, cordate-ovate in form, rather abruptly emarginate in front.

Fig. 2*a*. View of the base of a specimen.
Fig. 2*b*. Upper side of the same.
Fig. 2*c*. Posterior view.
Locality.—Leon Springs, Texas.

CYPHOSOMA TEXANUM.

PLATE I, FIG. 3, *a–c*.

Diadema Texanum, F. Roemer, Texas; p. 392.
Cyphosoma Texanum, Roemer, Kreidebildungen von Texas; p. 82, pl. x, fig. 6.

Orbicular, scarcely subangular, little elevated, depressed above, plane or concave below; tubercles of the ambulacral and interambulacral areas equal, distinctly crenulate; tubercles of the ambulacral areas biserial, intermediate tubercles few; tubercles of the interambulacral areas arranged in two principal series, and two slightly smaller accessory series, intermediate tubercles numerous, scattered.

The specimens of this species in the Boundary collections are fragmentary.

Fig. 3*a*. Profile view.
Fig. 3*b*. View of lower side.
Fig. 3*c*. Enlargement of surface, showing the ambulacral and interambulacral tubercles, pores, etc.
Locality.—Leon Springs, Texas.

HOLECTYPUS PLANATUS.

PLATE I, FIG. 4, *a, b, c, d, e, f*.

Orbicular or subpentagonal, moderately elevated, extremely depressed conical; inferior surface plane, concave in the middle; ambulacral areas somewhat prominent above the rest of the surface; tubercles small above, larger below, vent ovate, very large, reaching from the mouth to the margin.

The specimens present some variety in the greater or less elevation of the apex; the base is often convex near the margin, becoming gradually depressed towards the centre. The tubercles are very minute above, giving a sense of roughness to the touch, becoming larger on the sides and much larger below. The upper surface is often nearly smooth, while the lower surface retains the tubercles strongly preserved.

Fig. 4*a*. Profile view.

Fig. 4*b*. Upper surface.

Fig. 4*c*. View of the base.

Fig. 4*e*. Ambulacral and interambulacral spaces enlarged.

Fig. 4*f*., *g*. Enlargement of a tubercle of base.

TOXASTER ELEGANS.

PLATE XXI, FIG. 1 *a–e*.

Hemiaster elegans, Shumard, in Marcy's report of Exploration of the Red River of Louisiana; page 210, pl. 2, fig 4 *a*, *b*, *c*.

Shell subcordate-ovate, much elevated, apex anteriorly sub-central, rotund before, and emarginate in the middle by a sinus which terminates below in the mouth; obtuse or subtruncate behind, with a shallow depression below the vent; mouth transverse, round-oval, with a shallow depression on each side extending to the margin, anus oval, near the upper margin; the larger tubercles scattered upon the upper surface, and becoming more numerous and larger on the sides and lower margin; a triangular lanceolate space beginning near the mouth, and widening to the posterior extremity, covered with large tubercles, with a space on each side entirely smooth, or with a few scattered tubercles.

This species has the ambulacral areas defined by broad, shallow grooves, which, with the exception of the anterior one, extend to the upper outer margin of the test. It resembles in many of its characters the specimens which have been identified as *Toxaster Texanum*, but the apex is more nearly central (being anterior to the centre, while in that one it is posterior.) In the specimens under consideration, the ambulacral spaces are all deeply impressed, and the antero-lateral ones are more divergent; the anus is nearer the upper edge, and its greatest length is in a vertical direction. Although the figures of Dr. Shumard convey no very definite idea of the characters, yet his description is very satisfactory, and leaves little doubt regarding the identity of that species with the one under examination.

Fig. 1*a*. Upper side.

Fig. 1*b*. Lower side.

Fig. 1*c*. Profile of posterior end.

Fig. 1*d*. Lateral view in outline.

Fig. 1*e*. Enlargment of the surface.

Locality.—Eagle Spring, Texas.

BIVALVES.

CAPRINA, D'Orbigny.

CAPRINA OCCIDENTALIS.

Plate II, Figure 1, *a*, *b*, *c*.

Caprina occidentalis, Con. Proc. Acad. Nat. Sci. vol. VII, p. 268.

Falcate, flattened on the side of the outer curve, convex on the opposite, the other margins acutely rounded; surface very obscurely striated transversely, substance coarsely fibrous.

Locality.—Near the mouth of Puercos river.

CAPRINA PLANATA.

Plate II, Figure 2, *a*, *b*.

Caprina planata, Con. Proc. Acad. Nat. Sci. Vol. VII, p. 268.

Flattened on one side and convex on the opposite, much compressed, very long and narrow, falcate, fibrous, and exhibiting small septa.

A fragment of a valve, two feet in length, and another smaller fragment, are all of this species that I have seen. The cavities between the septa are lined with crystals of carbonate of lime, and both this and the preceding species are imbedded in white friable limestone.

Locality.—Oak creek, near Puercos.

TEREBRATULA, Lhwyd. Lam.

TEREBRATULA WACOENSIS.

Plate III, Figure 1.

Terebratula Wacoensis, Roemer, Kreide. von Texas, p. 81, pl. VI.

Inflated, semi-globose, pentagonal, smooth; front margin straight, not inflated, dorsal valve most convex; umbo obtuse, slightly incurved; area sufficiently distinct, circumscribed by an obtuse angle; ventral valve suborbicular, regularly convex; surface minutely punctate.

Locality.—

TEREBRATULA CHOCTAWENSIS.

Terebratula Choctawensis, Shumard, Geol. of Red river, p. 207, pl. II, fig. 3.

Suboval, truncated at base; both valves ventricose, surface elegantly marked with minute punctæ.

Locality.—Leon Springs.

TRIGONIA, Lam.

This interesting genus has been found as far down in the geological series as the triassic rocks. D'Orbigny enumerates ninety-nine species, and although there is one living representative on the coast of Australia yet the genus is unknown in the strata of tertiary periods.

TRIGONIA EMORYI.

PLATE III, FIGURE 2, *a*, *b*, *c*.

Trigonia Emoryi, Con. Proc. Acad. Nat. Sci., vol.

Inequilateral, obliquely truncated posteriorly, alated; obliquely ribbed; ribs about 34, narrow, prominent, compressed, or laterally abrupt, nodulose, diverging near the dorsal margin; ribs posteriorly, about the umbonal slope, composed of series of small nodules.

The form of this species approaches nearest to *T. crenulata*, but it is wider across the middle between the buccal and umbonal slope. The form of ribs is most nearly like those of *T. scabra*, but that shell has a wider anal area, and the dorsal depression is much smaller, being of a more ovate cuneate form.

Locality.—Between El Paso and Frontera.

TRIGONIA TEXANA.

PLATE III, FIGURE 3, *a*, *b*, *c*.

Trigonal cast of a large species, which is profoundly ventricose, truncated and direct on the ventral end, summits profoundly elevated; shell unknown.

Locality.—Leon Springs.

MACTRA, Lin. Lam.

MACTRA TEXANA.

PLATE IV, FIGURE 1, *a*, *b*.

Mactra Texana, Con. Proc. Acad. Nat. Sci., vol. VII, p. 269.

Triangular, ventricose, subequilateral, buccal end subangulated and slightly produced, much above the line of the base, which is regularly and profoundly curved, anal margin obliquely truncated, extremity angulated; buccal margin straight and very oblique; summit prominent.

This species is known from casts, and may prove to belong to the genus *Schizodesma*, Gray.

Locality.—Prairie between Laredo and Rio Grande city.

CUCULLÆA, Lam.

CUCULLÆA TERMINALIS.

PLATE IV, FIGURE 2, *a*, *b*.

Ovate-triangular, ventricose; buccal margin in the cast almost direct; anal side produced, cuneiform, extremity angulated; basal margin straight; summit profoundly prominent.

I have not seen the shell of this species. Comparing the casts with those of *C. vulgaris*, Morton, the summits are found to be much more prominent and more distant, as well as more nearly terminal.

Locality.—

ARCA, Lin.

ARCA SUBELONGATA.

PLATE VI, FIGURE 3, *a*, *b*.

Trapezoidal; anterior end regularly and rather acutely rounded; hinge and basal margins parallel· posterior extremity obliquely truncated.

Locality.—Between El Paso and Frontera.

ARCOPAGIA.

ARCOPAGIA TEXANA.

PLATE IV, FIGURE 3, *a*, *b*.

Arcopagia Texana, Roemer, Kreide. von Texas, pl. VI, fig. 8.

Orbicular, compressed, lentiform, inequivalve, subtortuous, cardinal margin nearly straight, forming an obtuse angle with the posterior margin; anterior muscular impression distinct, elongated, linguiform; posterior impression subrotund, approaching the cardinal margin; umbo small and slightly prominent.

CARDIUM, Lin. Lam.

CARDIUM MEDIALE.

PLATE IV, FIGURE 4, *a*, *b*.

Cordate, equilateral, ventricose; base profoundly and nearly regularly rounded; beaks prominent; posterior margin truncated, direct.

Locality.—

CARDIUM CONGESTUM.

PLATE VI, FIGURE 5, *a*, *b*, *c*, *d*.

Cordate, inflated, subequilateral; umbo prominent; beaks approximate; ribs radiating, probably about twenty-five in number.

An abundant species in the form of casts of entire specimens. A mere trace of the shell in one of these leads to the inference that the ribs were carinated. It has some general resemblance to *C. constantia*, D'Orbigny, but, unlike that species, it is oblique.

Locality.—Rio San Pedro.

CARDIUM, Sub-genus PROTOCARDIA, Beyrich.

The genus *Protocardia* of Beyrich was founded on the *Cardium Hillanum* of Sowerby. A number of species have been figured by authors—four have been described in D'Orbigny's Palæontologie Française. They are generally indicated by concentric lines or ribs, and have radiating striæ only on the post-umbonal area. The hinge resembles that of the Linnæan Cardium, and the species seem to pass into that genus, even through external characters. Nevertheless, they form a natural section, having no living representative, and characterizing the cretaceous and older tertiary formations.

CARDIUM (PROTOCARDIA) MULTISTRIATUM.

PLATE VI, FIGURE 4, *a*, *b*, *c*.

Cardium multistriatum, Shumard. Geol. of Red River, p. 207, pl. IV, fig. 2.

Subrotund, inflated, height and length nearly equal; truncated posteriorly; basal and anterior margins rounded; surface of posterior submargin, with 14–15 regular radiating striæ; remainder of surface marked with fine, equal, rounded, close concentric striæ; summit rather prominent.

Locality.—Leon Springs.

CARDIUM (PROTOCARDIA) TEXANUM.

PLATE VI, FIGURE 6, *a*, *b*, *c*.

Cardium Hillanum, Roemer, (not Sowerby,) Kreide. von Texas, p. 39, pl. VI, fig. 12.

Cordate, subquadrate, obliquely truncated posteriorly; umbo slightly oblique, submedial; disk concentrically ribbed; ribs large and prominent, rounded, laterally abrupt, fine and close on the umbo; post-umbonal area with about 17 tuberculated radiating lines.

Locality.—Between El Paso and Frontera.

CARDIUM (PROTOCARDIA) FILOSUM.

PLATE VI, FIGURE 7, *a*, *b*.

Triangular, elevated, with numerous minute, concentric lines anterior to the umbonal slope, which is obtusely carinated; umbonal and post-umbonal slopes marked with close, fine radii, about 30 in number.

This is the smallest species I have seen, and the only one with a carinated umbonal slope.

Locality.—Leon Springs.

CARDITA, Lam. Blainville.

CARDITA EMINULA.

PLATE VI, FIGURE 8.

Ovate-acute from beak to base, elevated; ribs 16, prominent, rounded? Those on the anterior slope angular, acute, umbo narrow, beaks pointed and elevated.

There is one specimen of this—a cast of both valves; there appear to be traces of radiating lines between the ribs.

Locality.—Leon Springs.

CORBULA.

CORBULA OCCIDENTALIS.

PLATE VI, FIGURE 9.

Allied to *C. oniscus*, Con.; but has finer and more numerous concentric furrows. It is probably an Eocene species; but was found in western Texas.

NEITHEA, Drouet.

This genus, it appears to me, should be restricted to that group of shells with an angular base of which *Pecten quinquecostatus*, Sowerby, is the type. So restricted, the genus is probably confined to the Cretaceous strata, and is certainly highly characteristic. No species of it occurs in Tertiary formations, nor in a living state.

NEITHEA OCCIDENTALIS.

PLATE V, FIGURE 1, *a*, *b*.

Neithea occidentalis. Conrad. Proc. Acad. Nat. Sci. vol. VII, p. 269.

Pecten quadricostatus, Roemer, (not Sowerby,) Kreide. von Texas, p. 64, pl. VIII, fig. 4.

Ovate-triangular; lower valve inflated, unequally ribbed, and concentrically striated, lines very fine; large ribs rounded and elevated, smaller ribs equal, two in number in each of the intervals of the larger ribs, which latter have on each side a raised line or fine rib, giving it a trifid character; upper valve subconcave.

This species differs from *P. quadricostatus*, Sowerby, in having but two equal ribs between the larger, while that species his three corresponding ribs, and it is also proportionally a narrower or more elevated shell.

NEITHEA TEXANA.

PLATE V, FIGURE 2, *a*, *b*.

Pecten Texanus, Roemer, Kreide. von Texas, p. 65, pl. VIII, fig. 3.

Orbiculate-triangular, plano-convex; inferior valve convex, with 15–17 ribs, which are subequal, broad, flattened, smooth, and bisulcate laterally, or margined on each side by a small rib: superior valve flat; ribs unequal, slightly prominent, flattened.

Locality.—Between El Paso and Frontera.

LIMA.

LIMA WACOENSIS.

PLATE V, FIGURE 4, *a*, *b*.

Lima Wacoensis, Roemer, Kreide. von Texas, p. 63, pl. VIII, fig. 7.

Oblong-oblique, transverse, anteriorly subtruncated, with radiating ribs, which are slightly unequal, anteriorly narrower, closer, subdichotomous.

LIMA LEONENSIS.

PLATE V, FIGURE 3, *a*, *b*, *c*.

Very oblique, elevated, of a somewhat oblong-oval outline; buccal side produced, compressed, angular at the extremity; margin above the extremity truncated, very oblique; below it the margin is also truncated, and parallel with the umbonal slope; basal margin rounded; anal extremity angulated; ears small; ribs about 19 in number, angular or subangular, and carinated on the middle; surface with fine radiating lines, and towards the base the ribs are more distinctly carinated than above.

This is a larger species than the preceding, and differs in form, in having carinated ribs, and in having the summit of the right valve much more prominent or elevated than the left; the ears are also smaller, and the margin much below the summit of the right valve. The largest specimen measures rather more than 1½ inches from beak to anal extremity.

Locality.—Leon Springs.

INOCERAMUS, Sowerby.

INOCERAMUS CONFERTIM-ANNULATUS.

PLATE V, FIG. 5.

Inoceramus confertim-annulatus, Roemer, Kreide. von Texas, p. 59, pl. VII, fig. 4.

Transverse, oval, depressed, concentrically undulato-plicated and striated, folds robust, regularly rounded; intervals of the wider folds hardly equal; elevated lines very fine, equidistant, regular on the fold, and intervals.

Locality.—Near New Braunfels.

INOCERAMUS MYTILOPSIS.

PLATE V, FIG. 6, *a*, *b*.

Inoceramus mytiloides, Roemer, (not Mantell,) Kreide. von Texas, p. 60, Pl. VII, fig. 5.

Oblique, elongate-ovate, inflated, concentrically plicated and striated; umbo very oblique, summit acute, prominent; buccal side short, extremity obtusely rounded, and the margin above and below subtruncated, the latter parallel with the anal margin, which is oblique and subtruncated; anal side somewhat compressed.

This species is more oblique than *I. mytiloides*, with a longer cardinal line; is proportionally less elevated, with the margins subangulated, while in the *I. mytiloides*, they are regularly or obtusely rounded.

INOCERAMUS TEXANUS.

PLATE V, FIG. 7.

Elevated, suboval, compressed, equilateral; hinge, and lateral, and basal margins regularly rounded; folds robust, prominent, unequal; summit not prominent.

Locality.—Western Texas.

INOCERAMUS CRISPII.

PLATE V, FIG. 8.

Inoceramus Crispii, Mantell, Foss. of South Downs, p. 133, Pl. XXVII, fig. 11.

Equivalve, elongate-ovate, transverse, inflated, concentrically undulato-plicate, elegantly and finely striated; anal side subdepressed, produced; buccal side short, obliquely subtruncated; cardinal margin long and straight.

This appears to be the same species that Dr. Morton described as *I. Barabini*, but his specimens were very imperfect.

Localities.—San Antonio, Texas; Green county, Alabama.

PHOLADOMYA, Sowerby.

PHOLADOMYA TEXANA.

PLATE XIX, FIG. 3.

A fragment of a cast, with 13–14 distant, prominent, narrow, somewhat undulated or irregular ribs; intervening spaces concave; concentric lines coarse, but not very prominent.

Locality.—Turkey creek, Leon and Eagle Pass roads.

ASTARTE, Sowerby.

ASTARTE TEXANA.

PLATE V, FIG. 9.

Triangular, convex-depressed; buccal extremity subangulated, and much above the line of the base, which is regularly rounded. A cast representing both valves.

The locality is unknown to me; it is from western Texas.

CYTHEREA, Lam.

CYTHEREA LEONENSIS.

PLATE VI, FIG. 1.

Oblong-subovate, ventricose, very inequilateral; posterior margin, from beak to extremity, slightly sinuous; extremity truncated or obtusely rounded, direct.

Locality.—Leon Springs, El Paso road.

CYTHEREA TEXANA.

PLATE VI, FIG. 2.

Obliquely-ovate, ventricose, very inequilateral, with prominent lines of growth; umbo large; umbonal slope subangulated; buccal margin obtusely rounded; base profoundly rounded; dorsal margin straight, very oblique.

Locality.—Between El Paso and Frontera.

PLICATULA, Lam.

PLICATULA INCONGRUA.

PLATE VI, FIG. 10, *a*, *b*.

Ovate, small, lower valve ventricose, with prominent entire ribs bifurcating from the umbo; superior valve flattened, with squamose, scarcely prominent, ribs; interstices linear.

Fig. 10 *a* represents the flat squamose valve, and fig. 10 *b* the opposite smooth-ribbed valve, as they appear in relief on a piece of hard limestone.

EXOGYRA, Say.

This genus, which is related to *Gryphæa*, originated in the Oolitic epoch. It widely differs from *Ostrea*, though some authors, even at the present day, include the species in that genus. The fact that all the species died out before the oldest Tertiary period, favors the idea that the animal was somewhat differently organized from that of *Ostrea*.

EXOGYRA ARIETINA.

PLATE VII, FIG. 1, *a–e*.

Exogyra arietina, Roemer, Kreide. von Texas, p. 68, pl. VIII, fig. 10.

Exogyra arietina, var. *caprina*, Con. Jour. Acad. Nat. Sci., Vol. II, new series, p. 273.

Ventricose; larger valve having the umbo spiral, or shaped like a ram's horn; back with obtuse or obsolete angles and furrows, and undulated, subimbricated lines of growth; upper valve nearly flat, with concentric lamellose lines. Very abundant. The variety *caprina* is generally elegantly marked with distinct, prominent, radiating, interrupted, subnodulose ribs. On the weathered surface of the rock they project in great perfection, and are crowded in vast numbers. It is related to *E. Pellicoi*, Gervais.

Locality.—Leon Springs.

EXOGYRA FIMBRIATA.

PLATE VII, FIGURE 2, *a*, *b*.

Exogyra fimbriata, Conrad, Proc. Acad. Nat. Sci., vol. VII, p. 269.

Upper valve very thick, very convex, with 10 or 12 distant, concentric, prominent, imbricated laminæ; surface of valve covered with minute, semi-granular, interrupted, rugose lines; inner surface minutely subgranular interiorly; apex nearly terminal; lower valve unkown.

Locality—Western Texas.

EXOGYRA LÆVIUSCULA.

PLATE VII, FIGURE 4, *a*, *b*.

Exogyra læviuscula, Roemer, Kreid. von Texas, p. 70, pl. IX, fig. 3.

Ovate, gibbous; larger valve inflated, subhemispherical, obtusely carinated in the middle, smooth, irregularly ornamented towards the margin, with a few larger lines of increment; umbo distinctly spiral; interior margin of the valve suborbicular, thin.

Locality—Leon Springs.

EXOGYRA MATHERONIANA.

PLATE VIII, FIG. 1, *a*, *b*; and PLATE XI, FIG. 1, *a*, *b*.

Exogyra Matheroniana, D'Orbigny, Palæon. Fran., vol. III, p. 717, pl. 485, fig. 1.
Exogyra plicata, Goldfuss, (not Lam.)
Exogyra Texana, Roemer, Kreid. von Texas, p. 69, pl. X, fig. 1.
Exogyra Texana, Shumard, Palæon. of Red river, p. 205, pl. V, figs. 1 and 5.

Obliquely ovate, convex, thick; larger valve carinate-angulate; ribs radiating, unequal and granulate-nodose; umbo exhibiting a point of attachment; smaller valve granulose, with radiating ribs, often thickened; inner margin finely striated; muscular impression semi-circular or ovate, submedial.

Locality—Between El Paso and Frontera.

EXOGYRA COSTATA, var.

PLATE VIII, FIGURE 2.

Exogyra ponderosa, Roemer, Kreid. von Texas, p. 71, pl. IX, fig. 2.

Large, thick, ovate, inflated, concentrically lamellose-striate; larger valve gibbous, obtusely carinated, concentric, lamellæ, irregular, imbricated, laciniate towards the margin; umbo spiral, free; smaller valve thick, concentrically laminated, within smooth; umbo distinctly spiral, horizontal.

EXOGYRA COSTATA.

PLATE IX, FIG. 1 and 2; PLATE X, FIG. 1; and PLATE VIII, FIG. 3.

Exogyra costata, Say. Jour. Acad. Nat. Sci., vol. II, p. 43. Morton, Synopsis, p. 55, pl. VI, fig. 1 and 4.

Suboval, thick; lower valve convex, costated, concentrically corrugated; costæ somewhat dichotomous, sometimes squamose; apex lateral, with about two volutions; muscular impression profound; upper valve with numerous elevated, concentric, squamose laminæ.

The Texan specimens agree in every respect with those of New Jersey and Alabama, and present the same varieties; some with, and others without, ribs, and every intermediate gradation.

Locality.—Jacun, three miles below Laredo.

EXOGYRA FRAGOSA.

PLATE VIII, FIGURE 2, *a*, *b*.

Exogyra fragosa, Con. Proc. Acad. Nat. Sci., vol. VII, p. 269.

Orbicular; lower valve ventricose posteriorly, flattened anteriorly; ribbed; ribs large and prominent, broad, irregular, some of them bifurcated, crossed by robust lamellar lines of growth; umbo small, flattened, very rough and strongly ribbed; inner margin rugosely striated; upper valve plano-convex, with a very uneven, subgranulated, rugose surface, and laminated towards the posterior and inferior margins; apex marginal.

A beautiful shell, differing from *E. ponderosa* or *costata* in having a much smaller umbo, wider ribs, and more rotund outline. The margins within are finely striated and anteriorly granulated. The upper valve is rugose-granulate interiorly. The figure does not well represent the elevation and inequality of the ribs.

Locality.—Between El Paso and Frontera.

GRYPHÆA, Lam.

GRYPHÆA PITCHERI.

PLATE VII, FIG. 3; and PLATE X, FIG. 2, *a*, *b*.

Gryphæa Pitcheri, Morton, Synopsis, p. 55, pl. XV, fig. 9.

Gryphæa dilatata, var. *Tucumcarii*, Marcou, Bul. de la Soc. Geol. de France, vol. XII, (May, 1855,) pl. XXI, fig. 3.

Ovate, gibbous, somewhat regular; inferior valve inflated, arcuate, lobed; lines of growth subimbricate; umbo large, prominent, subcompressed, incurved; smaller valve thick, with faint, impressed, radiating lines, compressed or laterally flattened above on the anterior side, slightly concave in the middle; surface concentrically imbricate-striate.

This widely-spread species occurs in all the localities in two distinct forms: one resembling *G. vesicularis*, and which is the type of the species as figured and described by Morton; and the other, truncated anteriorly, with a narrow, elongated, boat-shaped umbo, var. *navia*, pl. VII, fig. 3, *c*, *d*. The upper valve of the typical form is represented in pl. X, fig. 2, *a*, *b*. Roemer has given excellent figures of the var. *navia*.

Localities.—Leon Springs, Texas; plains of the Kiamesha, Arkansas; New Braunfels, Texas; Fort Washita and Cross Timbers, Texas.

OSTREA, Linn.

OSTREA SUBSPATULATA.

PLATE X, FIGURE 3, *a*, *b*.

Ostrea subspatulata, Lyell and Sowerby, Jour. Geol. Soc. London, vol. I, p. 61, (figured.)

Obovate; somewhat trapeziform, generally thick; higher than wide, narrower at the dorsal than at the ventral or basal end, which is turned downwards at an obtuse angle; somewhat foliaceous externally; muscular impression placed very near the base.

This species approximates *O. Leymerii*, Desh. It was first discovered by Lyell in North Carolina, associated with *Belemnites mucronatus* and *Gryphæa vesicularis*. This group appears to represent the age of the *Gryphæa* and *Exogyra* beds of New Jersey.

Locality.—Western Texas.

OSTREA BELLA.

PLATE X, FIGURE 4, *a*, *b*.

Oblong-ovate, slightly curved; lower valve ventricose, undulated, with somewhat interrupted, radiating ribs, crossed by remote squamose concentric lines; beak produced; lesser valve flat, concave towards the base, marked by minute, obsolete, radiating lines.

Locality.—Western Texas.

OSTREA LUGUBRIS.

PLATE X, FIGURE 5.

Suboval; superior valve flat; inferior valve slightly ventricose, showing a mark of attachment on the umbo; ribs radiating, prominent, rugose, disappearing on the umbo. A small species, constant in character, and easily recognized.

Locality.—East of Red river, (Canadian,) New Mexico, Santa Fé road.

OSTREA CARINATA.

PLATE X, FIGURE 6.

Ostrea carinata, Lam. An. sans vert, Desh. ed. vol. VII, p. 240.
Ostrea carinata, Roemer, Kreid. von Texas, p. 75, pl. IX, fig. 5.

Subequivalve, elongated, arched, compressed, eared anteriorly, regularly plicated; folds equal, acute, carinated, diverging from a flattened surface on the back, geniculated at the angle and vertical on the sides, which are flattened.

I have not seen good specimens of this shell, and refer it to *carinata* chiefly on the authority of Roemer.

Localities.—Turkey creek, Las Minas; New Braunfels.

OSTREA VELLICATA.

PLATE XI, FIGURE 2, *a*, *b*.

Subovate, inferior valve convex, with very irregular, laminated, concentric lines, imbricated; surface as if pinched into cavities in places; beak subrostrated, thick; margins of the lower valve thickened, muscular impression comparatively near the base; hinge area broad.

I have seen but one valve of this species.

Locality.—Rio Grande, between El Paso and Frontera.

OSTREA ROBUSTA.

PLATE XI, FIGURE 3, *a*, *b*.

Elevated, subfalcate, thick; inferior valve convex; superior valve flattened, with rather distant subimbricated laminæ; apex truncated.

There are only two specimens of this species; the outer surface of the lower valve is abraded, and the characters obliterated; the upper valve in one is much thickened on the margins, which are crenulated within on the upper part.

Locality.—Jacun, three miles below Laredo.

OSTREA CORTEX.

PLATE XI, FIGURE 4, *a, d.*

Elongated, pointed towards the apex; inferior valve ventricose, very thick, with very prominent, concentric, imbricated laminae; cardinal fosset long and profound, somewhat curved, with a rounded ridge on each side.

A remarkable species, with a rough bark-like exterior; the upper valve is somewhat ventricose and marked like the opposite exteriorly.

Locality.—Dry creek, Mexico.

OSTREA MULTILIRATA.

PLATE XII, FIGURE 1, *a, d.*

Sub-triangular, thick and ponderous, somewhat curved; both valves flattened, irregularly undulated concentrically, and having numerous radiating, interrupted folds; umbo flat, very thick; cardinal fosset long and somewhat curved, deep, cavity very shallow.

This is a remarkable species, very variable in form. I know of no cretaceous species like this or the preceding, and as no other fossil was obtained with these, their geological age is uncertan; possibly they may belong to strata of earlier date than the cretaceous rocks of Texas.

Locality.—Dry creek, Mexico.

UNIVALVES.

NATICA, Lam.

NATICA TEXANA.

PLATE XIII, FIGURE 1, *a, b.*

Suboval; volutions, 5; rounded; spire prominent.

Locality.—Between Rio San Pedro and Rio Puercos.

NATICA COLLINA.

PLATE XIII, FIGURE 2, *a, b.*

This specimen may be the young of the former species. The cast is distorted and imperfect.

Locality.—Same as preceding.

ROSTELLARIA? Lam.

ROSTELLARIA? COLLINA.

PLATE XIII, FIGURE 3, *a, b.*

One or two imperfect casts of this fossil occur with the preceding *Natica*.

ROSTELLARIA? COLLINA.

PLATE XIII, FIGURE 4, *a*, *b*.

Elliptical; volutions, 6; those of the spire rounded; body volution, with a rather wide, slight, revolving depression near the suture.—(A cast.)

BUCCINOPSIS.

BUCCINOPSIS PARRYI.

PLATE XIII, FIGURE 4, *a*, *b*.

Sub-pyriform; longitudinally undulated and ornamented with rugose revolving lines; volutions flattened above; spire scalariform; aperture large and patulous.

Under this name I have described a cast which cannot be referred with accuracy to any known genus. The beak is broken and was probably produced.

Locality.—Same as preceding.

TURRITELLA, Lam.

TURRITELLA PLANILATERIS.

PLATE XIV, FIGURE 1, *a*, *b*.

Subulate; volutions with two large beaded revolving lines, and two smaller ones beneath, with an intermediate fine crenulated line; sides straight; the upper large revolving line gives the shell a carinated character.

Very distinct from *T. seriatum-granulatum*, Roemer. The shell and sculpture are in perfect preservation. It is accompanied by *Lima Leonensis*, a small *Natica*, and a small *Astarte*, which has about five broad concentric prominent ribs, and triangular in form. It may be named *Astarte crassilira*.

ROSTELLITES, Conrad.

ROSTELLITES TEXANA.

PLATE XIV, FIGURE 2, *a*, *b*.

Rostellites Texana, Con. Proc. Acad. Nat. Sci. Vol. VII, p. 268.

Narrow, elongated, with a subulate spire; plaits of columella oblique, straight, narrow, acute, largest above, and becoming obsolete towards the base; volutions of the spire flattened on the sides.

The above genus is probably related to Pterocera. The specimens are very imperfect, only one of them retaining any portion of the shell, and this is the columella with the plaits.

Locality.—Eagle Pass.

NERINEA, Defranc.

NERINEA SCHOTTII.

PLATE XIV, FIGURE 3, *a*, *b*.

Elongated; volutions concave or sub-angulated below the middle; destitute of lines except one slightly impressed line near and below the suture; body volution angulated in the middle.

A large and beautiful species, with the shell converted into carbonate of lime. Named in honor of its discoverer, Arthur Schott, esq.

NODOSARIA, Lam.

NODOSARIA TEXANA.

PLATE XIV, FIGURE 4, *a*, *b*, *c*.

Straight or slightly curved, subulate, nodes transversely oblong or depressed, ventricose, numerous.

Very abundant in the form of casts. The outline of the shell appears to have been nearly or quite straight below, and somewhat curved towards the apex.

Locality—Between El Paso and Frontera.

AMMONITES, Lam.

AMMONITES PLEURISEPTA.

PLATE XV, FIG. 1, *a*, *b*, *c*.

Discoid, much compressed, lentiform ; back acute ; volutions with obscure, distant, transverse ribs or undulations, and two series of nodules—one central and distinct, the other obsolete—elongated transversely and near the margin or back; transverse section of the whorls lanceolate; umbilicus very small; series of sutures of the septa crowded, gradually separating as they approach the inmost whorl ; septal lobes short, suddenly expanded, crenulate, rounded; saddle bilobed, the lobes obtusely rounded, the third lobe from the dorsal the largest of the series.

This species approximates *A. pedernalis*, Roemer, who supposes it to be identical with the foreign species of that name described by Von Buch. It differs from Roemer's shell in having tubercles, in being less compressed, or forming a less acute angle with the back; in having a smaller umbilicus, and transverse undulations, and also in more crowded and very differently shaped septa. It attains a much larger size than the specimen figured.

Locality.—Jacun, 3 miles below Laredo.

AMMONITES GENICULATUS.

PLATE XV, FIG. 2, *a*, *b*.

Discoid, sides flattened and gradually sloping towards the back, which is abrupt, slightly rounded, and with a thick, prominent carina on the middle; ribs numerous, slightly curved until they approach the back, when they suddenly bend and become very oblique and more prominent, obsolete on the back ; inner sides of the volutions abrupt.

Allied to *A. flaccidicosta*, Roemer, but may be distinguished by the dorsal carina and broader arms of the septal lobes, and flattened instead of rounded volutions ; and also by the different form and inclination of the ribs.

Locality.—Bed of Rio San Pedro, and Leon Springs.

AMMONITES TEXANUS.

PLATE XVI, FIG. 1, *a*, *d*.

Ammonitse Texanus, Roemer ; Kreid. von Texas, pl. VI, fig. 2, *a*, *b*.

Large, somewhat discoidal, involute ; volutions subquadrangular, gradually increasing in height and width, carinated and nodo-costate; dorsal carina continuous, the approximate series of tubercles not equal to it in prominence; ribs numerous, 22 on each volution, equidistant, ornamented with 5 tubercles; series near the dorsal carina compressed, elongated, the others rounded; transverse section of the exterior volution rectangular, of the interior volution quadrate; sutures of septa moderately divided and ramose.

Locality.—Near Puercos river.

AMMONITES LEONENSIS.

PLATE XVI, FIG. 2, *a*, *b*.

Volutions with thick, distant, rounded ribs, with a tubercle on each extremity and an intermediate rudimentary rib, having a tubercle on the dorsal angle; back obliquely truncated on each side of the carina.

This shell differs from *A. Texanus* in having the back elevated in the middle, and in being without tubercles on the back, in having only two series of nodes on the sides, or with a middle series of rudimentary or obsolete tubercles; also the serratures of the septal lobes are much wider than in *A. Texanus*.

TERTIARY FOSSILS.

OSTREA, Lin.

OSTREA VESPERTINA.

PLATE XVII, FIG. 1, *a–d*.

Ostrea vespertina, Con. Jour. Acad. Nat. Sci., vol. II, (new series) p. 300.

Ovate-subfalcate; lower valve plaited or ribbed; hinge long and wide, sharp and somewhat pointed; ligament cavity wide, profound, minutely wrinkled; margins abrupt; cavity not very deep; muscular impressions large, impressed; upper valve flat, irregular; pallial impression crenulated.

Resembles *O. subfalcata*, Con. of the Virginia Miocene.

Localities.—Carriso creek, and near San Diego, California. (Miocene.)

OSTREA VELENIANA.

PLATE XVII, FIG. 2, *a*, *b*.

Ovate, flattened, entire, with rugose lines of growth; cardinal area very broad: ligament pit shallow; muscular impression very large in proportion to the size of the shell, transverse; no crenulations visible about the margin.

This is probably a Miocene shell.

Locality.—Rancho Heleña, below Salado.

OSTREA CONTRACTA.

PLATE XVIII, *a*, *b*, *c*, *d*.

Ostrea contracta, Proc. Acad. Nat. Sci., vol. VII, p. 269.

Subfalcate, elongate, thick; exterior of lower valve very irregular, and varying from ventricose to flat; cavity shallow and remarkably contracted towards the hinge, which is elongated, having a deep and broad cavity in the lower valve, with a corresponding rounded and striated ridge in the opposite valve.

This large oyster measures nearly two feet from beak to base. The contracted form of the cavity is most striking in the oldest individuals. Probably a Miocene shell.

Locality.—Oyster Point, Mexico.

ANOMIA, Lin.

ANOMIA SUBCOSTATA.

Plate XIX, Fig. 1 *a*, *b*.

Anomia subcostata, Con. Proc. Acad. Nat. Sc., vol. VII, p. 267.

Obtusely ovate, rather thick; umbo of larger valve ventricose; hinge thickened, surface of the valve obtusely undulated concentrically, and marked with waved, wrinkled, interrupted ribs, much raised, except towards the base, where they are larger and somewhat tuberculiform; upper valve entire, or with obsolete radii towards the base.

This has a general resemblance to *A. Ruffini*, Con., of the Virginia Miocene, but is much thicker and very distinct.

CARDITA, Lam. Blain.

CARDITA PLANICOSTA.

Plate XIX, Figure 2, *a*, *b*.

Venericardia planicosta, Lam. An. sans Vert., vol. V, p. 669. Desh. Coq. Foss., vol. I, p. 149.
Cardita planicosta, Blainville.

Ovate-oblique, cordate, very thick, with flattened broad ribs, 22–24, granulated towards the apex; lunule very profound, wide, cordate, margin crenate within, cardinal teeth two, finely striated.

This species is found in Virginia and Alabama, as well as in California. Deshayes describes the Paris specimens of *C. planicosta* as crenulated on the ribs near the summit, a character scarcely visible in the specimens that I have examined.

Locality.—Arroyo las Minas, between Eagle Pass and Leon.

CORBULA, Lam.

CORBULA NASUTA.

Plate XIX, Figure 4.

Corbula nasuta, Con. Foss. Shells of Tert. Form.
Corbula Alabamiensis, Lea, Cont. p. 45, pl. I, fig. 12.

Inflated, triangular-ovate, very inequivalve, ventricose; finely striated concentrically; buccal end rounded, longer than the anal, which is contracted; flexuous, narrow, and obliquely truncated at the end.

Locality.—Western Texas.

VENUS VESPERTINA.

PLATE XIX, FIGURE 5, *a*, *b*.

Subtriangular, inequilateral, convex ; length and height equal ; buccal end acutely rounded; anal end more obtuse ; summit prominent.

A small Eocene species, with the external surface somewhat worn. It appears to have had concentric lines.

Locality.—Western Texas.

CYTHEREA, Lam.

CYTHEREA NUTTALI.

PLATE IV, FIGURE 5.

Cytherea Nuttali, Con. Foss. Shells of Tert. Form.

Subrotund, inflated, equilateral, ornamented with fine, regular, concentric lines, anal end obtusely rounded.

An Eocene species, found both in Texas and Alabama.

Locality.—East of Frontera, associated with *Cassidula alveata.*

VOLUTALITHES, Swainson.

VOLUTALITHES SAYANA.

PLATE XIX, FIGURE 6.

Voluta Sayana, Con. Foss. Shells of Tert. Form.
Voluta Defrancii, Lea, Cont., p. 171, pl. VI, fig. 179.
Voluta gracilis, Lea, Cont., p. 172, pl. VI, fig. 180.
Voluta parva, Lea, Cont., p. 173, pl. VI, fig. 181.

Turbinate, with revolving impressed lines ; coronated ; shell thin; volutions 7, subangulated; body volution either smooth or with longitudinal acute lines or folds.

There is only one small specimen of this abundant Claiborne species. It is imbedded in the same piece of rock which contains *Corbula nasuta* and *Natica limula.*

Locality.—Western Texas.

NATICA, Lam.

NATICA LIMULA.

PLATE XIX, FIGURE 7.

Natica limula, Con. Foss. Shells of Tert. Form.
Natica mamma, Lea, Cont. to Geol., p. 109, pl. IV, fig. 95.

Subglobose, flattened at base ; spire rounded, pointed at the apex; columella much thickened above ; umbilicus large ; shell thin ; mouth ovate.

Locality.—Same as preceding.

TURRITELLA, Lam.

TURRITELLA ———.

PLATE XIX, FIGURE 8.

This figure represents a specimen of tertiary rock from San Diego, California. Besides the *Turritella*, which is not determined, there are a few small unknown bivalves.

CASSIDULA, Humphreys. Sub-genus LACINIA, Con.

CASSIDULA ALVEATA.

PLATE XIX, FIGURE 9.

Melongena alveata, Con., Amer. Jour. Sci., vol. XXIII, p. 344.
Cassidula alveata, Con., Proc. Acad. Nat. Sci., vol. VII, p. 448.
Pyrula Smithii, Lea, Cont. to Geol., p. 153, pl. V, fig. 162.

Sub-globose, with revolving robust lines, and a wide, concave, revolving furrow below the angle of the large volution; spire very short; suture deeply impressed, sub-canaliculate.

Locality.—Western Texas.

APPENDIX.

CRETACEOUS FOSSILS.

CARDITA SUBTETRICA.

PLATE XXI, FIGURE 5.

Sub-orbicular, slightly ventricose; ribs 22? not very prominent, rounded, squamose, ribs and interstices about equal in width.

This may be an eocene species; I do not know any of its associated fossils.

Locality.—Rio Bravo del Norte.

PHOLADOMYA SANCTI-SABÆ.

PLATE XXI, FIGURE 4.

Cardium Sancti-Sabæ, Rœmer, Kreide. von Texas, p. 48, pl. VI, fig. 7.

Inequilateral, longitudinally ovate, gibbous, posteriorly compressed, produced, sub-caudate, smooth; the rest of the shell radiate-costate; ribs 16, equal, granulated, becoming obsolete posteriorly; umbo large, prominent, anterior to the middle.

Localities.—Leon Springs; New Braunfels, Texas.

CAPSA, Lam.

CAPSA TEXANA.

PLATE XXI, FIGURE 6.

Oblong-oval, disk flattened or depressed in the middle; radii distinct, close, rugose posteriorly, gradually becoming obsolete in the middle of the valve; buccal end regularly rounded; anal end truncated, direct.

Locality.—Leon Springs.

TEREBRATULA LEONENSIS.

PLATE XXI, FIGURE 2.

Inequivalved, oval or sub-petagonal; rostral end ventricose, rounded in the middle, and the sides obliquely convex-depressed; umbo small; foramen small, almost touching the umbo; imperforate valve less convex; valve widest above the middle, rapidly tapering to the front, which is slightly depressed; front margin narrow and truncated; surface elegantly and minutely punctate.

Narrower in front than *T. Wacoensis*, Rœmer. I cannot compare it with Shumard's figure of *T. Choctawensis*, as that figure, in the Palæontology of Red river, like all the representations of fossils in that work, (except *Gryphœa Pitcheri*,) is worthless for the purpose of identification. The punctuated surface is so common in the genus that it has no value in specific distinctions.

Locality.—Leon Springs.

TURRITELLA LEONENSIS.

PLATE XXI, FIGURE 7, *a*, *b*.

Volutions sub-angular, each with three distant, large, crenulated, revolving ribs, and an intermediate crenulated line ; spire rapidly tapering to the apex ; body volution large, rounded at base, which has four or five fine revolving ribs.

A limestone cast ; traces of shell show oblique longitudinal folds or ribs.

HAMITES LARVATUS.

PLATE XXI, FIGURE 8.

Hamites larvatus, Con. Proc. Acad. Nat. Sci., vol. VII, p. 265.

Ovate-oval, obliquely ribbed ; beak and front obtusely rounded or sub-truncated ; ribs oblique, distant, very prominent, acute, unequal, frequently alternated, obsolete on the back, and having a tubercle on the front margin or angle ; ribs on the front thickened and obtuse ; sides of the shell flattened, and the rib margin nearly rectilinear ; smaller ribs generally without a distinct tubercle.

I have amended the former description of this species from the specimen here figured. In the Arkansas specimen the ribs are alternated, the smaller one being without a tubercle ; but the former has three equal ribs with the tubercle on each, and above them is the smaller rib without it. Traces of the shell show annular striæ.

Localities.—Leon Springs, Texas ; White river, Arkansas.

EXPLANATION OF PLATES OF PROFESSOR HALL'S REPORT.

PLATE I.

Fig. 1.—PYRINA PARRYI.

Fig. 1 *a*. Upper side.
1 *b*. Lower side.
1 *c*. Posterior side.
1 *d*. Enlargement of the surface showing the larger and smaller granulations, ambulacral pores, etc.

Fig. 2.—TOXASTER TEXANUS.

Fig. 2 *a*. View of the base.
2 *b*. View of the summit.
2 *c*. Posterior view.

Fig. 3.—CYPHOSOMA TEXANUM.

Fig. 3 *a*. Profile view.
3 *b*. View of base.
3 *c*. Enlargement of ambulacral and interambulacral spaces, (figures from Roemer.)

Fig. 4.—HOLECTYPUS PLANATUS.

Fig. 4 *a*. Profile view.
4 *b*. Summit.
4 *c*. Base.
4 *d*. Enlargement of the summit of the test.
4 *e*. Enlargement of the ambulacral and interambulacral spaces.
4 *f*, *g*. Base of attachment of spine enlarged.

PLATE II.

Fig. 1.—CAPRINA OCCIDENTALIS.

Fig. 1 *a*, *b*. Upper and lower sides.
1 *c*. Transverse section.

Fig. 2.—CAPRINA PLANATA.

Fig. 2 *a*. A fragment one third the linear dimensions.
2 *b*. Enlargement showing structure.

Fig. 3.—TURBINOLIA TEXANA

Fig. 3 *a*. Specimen natural size.
3 *b*. Enlargement of the lamellae.

PLATE III.

Fig. 1.—TEREBRATULA WACOENSIS.

Fig. 1 *a*. Dorsal view.
1 *b*. Ventral view.
1 *c*. Profile view.
1 *d*. Enlargement of surface.

Fig. 2.—TRIGONIA EMORYI.

Fig. 2 *a*. Posterior view.
2 *b*. Anterior view.
2 *c*. Right valve.

Fig. 3.—TRIGONIA TEXANA.

Fig. 3 *a*. Lateral view.
3 *b*. Posterior view.
3 *c*. Anterior view.

PLATE IV.

Fig. 1.—MACTRA TEXANA.

Fig. 1 *a*. Lateral view.
1 *b*. Cardinal view.

Fig. 2.—CUCULLEA TERMINALIS.

Fig. 2 *a*. Lateral view.
2 *b*. Anterior cardinal view.

Fig. 3.—ARCOPAGIA TEXANA.

Fig. 3 *a*. Lateral view.
3 *b*. Cardinal view.

Fig. 4.—CYTHEREA NUTTALLI.

Fig. 4 *a*. Lateral view.
4 *b*. Cardinal view.

PLATE V.

Fig. 1.—NEITHEA OCCIDENTALIS.

Fig. 1 *a*. Lower valve.
1 *b*. Profile view.
1 *c*. Enlargement of the surface.

Fig. 2.—NEITHEA TEXANA.

Fig. 2 *a*. Lower valve.
2 *b*. Enlargement of surface.

Fig. 3.—LIMA LEONENSIS.

Fig. 3 *a*. Right valve.
3 *b*. Postero-cardinal view.
3 *c*. Enlargement of surface.

FIG. 4.—LIMA WACOENSIS.

Fig. 4 *a*, *b*. Lateral and cardinal views.

FIG. 5.—INOCERAMUS CONFERTIM ANNULATUS.

FIG. 6.—INOCERAMUS MYTILOPSIS.

Fig. 6 *a*. Figure, (after Roemer.)
6 *b*. Fragment of New Mexican specimen.

FIG. 7.—INOCERAMUS TEXANUS.

FIG. 8.—INOCERAMUS CRISPII.

FIG. 9.—ASTARTE TEXANA.

PLATE VI.

FIG. 1.—CYTHEREA LEONENSIS.

FIG. 2.—CYTHEREA TEXANA.

FIG.—3.—ARCA SUB-ELONGATA.

Fig. 3 *a*. Left valve.
3 *b*. Cardinal view.

FIG. 4.—CARDIUM MULTISTRIATUM.

Fig. 4 *a*. Right valve.
4 *b*. A larger individual.
4 *c*. Profile view.

FIG. 5.—CARDIUM CONGESTUM.

Fig. 5 *a*. Right valve.
5 *b*. Posterior view.
5 *c*. A larger individual.
5 *d*. Profile of same.

FIG. 6.—CARDIUM TEXANUM.

Fig. 6 *a*. Right valve.
6 *b*. Posterior view.
6 *c*. Anterior view.

FIG. 7.—CARDIUM FILOSUM.

Fig. 7 *a*. Left valve.
7 *b*. Enlargement of surface.

FIG. 8.—CARDITA EMINULA.

Fig. 8. Lateral and profile views.

FIG. 9.—CORBULA OCCIDENTALIS.

FIG. 10.—PLICATULA INCONGRUA.

Fig. 10 *a*. Lower valve.
10 *b*. Upper valve and interior of lower valve.

PLATE VII.

Fig. 1.—EXOGYRA ARIETENUM.

Fig. 1 *a*. Upper valve, exterior view.
1 *b*. Upper valve, interior.
1 *c*. Lower valve.
1 *d*, *e*. Two views, same specimen.

Fig. 2.—EXOGYRA FOLIACEA.

Fig. 2 *a*. Upper valve, exterior surface.
2 *b*. Upper valve, interior surface.

Fig. 3.—GRYPHÆA PITCHERI.

Fig. 3 *a*. Lower valve, exterior surface.
3 *b*. View of upper side of shell, with valves attached.
3 *c*. Profile of large valve.
3 *d*. Large valve, variety *navia*.
3 *f*. Upper valve, exterior view.
3 *g*. Upper valve, interior view.

Fig. 4.—GRYPHÆA LÆVIUSCULA.

Fig. 4 *a*. Lower valve.
4 *b*. Profile of same.

PLATE VIII.

Fig. 1.—EXOGYRA MATHERONIANA.

Fig. 1 *a*. Lower valve.
1 *b*. Anterior view.

Fig. 2.—EXOGYRA FRAGOSA.

Fig. 2 *a*. Lower valve, exterior view.
2 *b*. Lower valve, interior view.

Fig. 3.—EXOGYRA TEXANA—variety.

PLATE IX.

Fig. 1.—EXOGYRA COSTATA—variety.

Fig. 1. Exterior view of specimen fig. 3 of the preceding plate.

Fig. 2.—EXOGYRA COSTATA.

Fig. 2 *a*. Exterior view of lower valve.
2 *b*. Interior of lower valve.

PLATE X.

Fig. 1.—EXOGYRA COSTATA.

Fig. 1. Exterior view of the lower valve, showing the obsolescent character of the costæ.

FIG. 2.—GRYPHÆA PITCHERI.

Fig. 2 *a*. Exterior of upper valve.
2 *b*. Interior of the same.

FIG. 3.—OSTREA SUBSPATULATA.

Fig. 3 *a*. Exterior view of the upper valve.
3 *b*. Interior of the same.

FIG. 4.—OSTREA BELLA.

Fig. 4 *a*. View of the upper side of the two valves attached.
4 *b*. Lower valve, exterior view.

FIG. 5.—OSTREA LUGUBRIS.

Fig. 5 *a*, *b*. Exterior and interior of lower valve.

FIG. 6.—OSTREA CARINATA.

PLATE XI.

FIG. 1.—EXOGYRA MATHERONIANA.

Fig. 1 *a*, *b*. Exterior and interior views of lower valve.

FIG. 2.—OSTREA VELLICATA.

Fig. 2 *a*, *b*. Exterior and interior views of lower valve.

FIG. 3.—OSTREA ROBUSTA.

Fig. 3 *a*. Upper side, with the shell exfoliated.
3 *b*. Lower side, retaining the shell, in part.

FIG. 4.—OSTREA CORTEX.

Fig. 4 *a*, *b*. Exterior and interior of a lower valve.
4 *c*, *d*. Exterior and interior of an upper valve.

PLATE XII.

FIG. 1.—OSTREA MULTILIRATA.

Fig. 1 *a*, *b*. Exterior and interior of upper valve.
1 *c*, *d*. Exterior and interior of lower valve, showing a different form.

PLATE XIII.

FIG. 1.—NATICA TEXANA.

Fig. 1 *a*, *b*. wo views of same specimen.

FIG. 2.—NATICA COLLINA.

Fig. 2 *a*, *b*. Two views of the same specimen.

FIG. 3.—ROSTELLARIA? COLLINA.

Fig. 3 *a*, *b*. Two views of the same specimen.

FIG. 4.—ROSTELLARIA? TEXANA.

Fig. 4 *a*, *b*. Two views of the same specimen.

FIG. 5.—BUCCINOPSIS PARRYI.

Fig. 5 *a*, *b*. Two views of the same specimen.

PLATE XIV.

FIG. 1—TURRITELLA PLANILATERIS.

Fig. 1 *a*. A fragment of the shell, natural size.
1 *b*. A part of the surface, enlarged.

FIG. 2.—ROSTELLITES TEXANA.

Fig. 2 *a*, *b*. Two views of same specimen.

FIG. 3.—NERINEA SCHOTTII.

Fig. 3 *a*, *b*. Two views of same specimen.

FIG. 4—NODOSARIA TEXANA.

Fig. 4 *a*. Exterior view of specimen, enlarged.
4 *b*. Longitudinal section.
4 *c*. A transverse section.

PLATE XV.

FIG. 1.—AMMONITES PEDERNALIS, (Var.)

Fig. 1 *a*. Lateral view.
1 *b*. Front view.
1 *c*. Plan of septa, enlarged.

FIG. 2.—AMMONITES GENICULATUS.

Fig. 2 *a*. Lateral view.
2 *b*. Front view.

PLATE XVI.

FIG. 1.—AMMONITES TEXANUS.

Fig. 1 *a*. Lateral view.
1 *b*. View of aperture.
1 *c*. Plan of septa, enlarged.
1 *d*. Young variety, (after Rœmer.)

FIG. 2.—AMMONITES LEONENSIS.

Fig. 2 *a*. Lateral view.
2 *b*. Aperture, &c.

PLATE XVII.

FIG. 1.—OSTREO VESPERTINA.

Fig. 1 *a*, *b*. Exterior and interior of upper valve.
1 *c*, *d*. Exterior and interior of lower valve.

FIG. 2.—OSTREO VELENIANA.

Fig. 2 *a*, *b*. Exterior and interior of upper valve.

PLATE XVIII.

FIG. 1.—OSTREA CONTRACTA.

Fig. 1 *a*. Exterior view of a narrow valve.
1 *b*. Exterior view of a shell of the usual form.
1 *c*. Interior and lateral view of larger valve. (Figures one-third, in linear measurement, of the originals.)
1 *d*. Enlargement of surface of the ligamental pit.

PLATE XIX.

FIG. 1.—ANOMIA SUBCOSTATA.

Fig. 1 *a*, *b*. Exterior and interior of lower valve.

FIG. 2.—CARDITA PLANICOSTA.

Fig. 2 *a*. Left valve, natural size.
2 *b*. Enlargement of surface, showing concentric striæ.

FIG. 3.—PHOLADOMYA TEXANA.

FIG. 4.—CORBULA NASUTA.

FIG. 5.—VENUS VESPERTINA.

Fig. 5 *a*. Right valve, natural size.
5 *b*. Enlargement of surface.

FIG. 6.—VOLUTALITHES SAYANA.

FIG. 7.—NATICA EMINULA.

FIG. 8.—TURRITELLA ——— ?

FIG. 9.—CASSIDULA (LACINIA) ALVEATA.

Fig. 9 *a*. View of the aperture.
9 *b*. Back of the shell.

PLATE XX.

FIG. 1.—COLUMNARIA THOMI.

Fig. 1 *a*. A fragment of stone with the coral, (ends of columns,) natural size.
1 *b*. Lateral view of same.
1 *c*. Longitudinal section enlarged.
1 *d*. Transverse section enlarged.

FIG. 2.—TEREBRATULA MEXICANA.

Fig. 2 *a*, *b*, *c*. Dorsal, ventral and profile views.

FIG. 3.—ORTHIS ARACHNOIDES?

Fig. 3 *a*. Shell, natural size.
3 *b*. Enlargement of striæ.

FIG. 4.—EUOMPHALUS MICHLERANUS.

FIG. 5.—ASAPHUS EMORYI.

PLATE XXI.

FIG. 1.—HOLASTER ELEGANS.

Fig. 1 *a*. View of summit of specimen.
1 *b*. Base of same.
1 *c*. Posterior, profile view.
1 *d*. Lateral view, profile in outline.
1 *e*. Enlargement of surface.

FIG. 2.—TEREBRATULA LEONENSIS.

Fig. 2 *a*, *b*. Dorsal and profile views.
2 *c*. Enlargement, showing punctate character of shell.

FIG. 3.—GRYPHÆA PITCHERI.

Fig. 3 *a*. View of upper side of specimen with the two valves attached.
3 *b*. Exterior of the lower valve of same.
3 *c*. Interior of lower valve of a smaller individual.

FIG. 4.—PHOLODOMYA, SANCTA-SABLÆ.

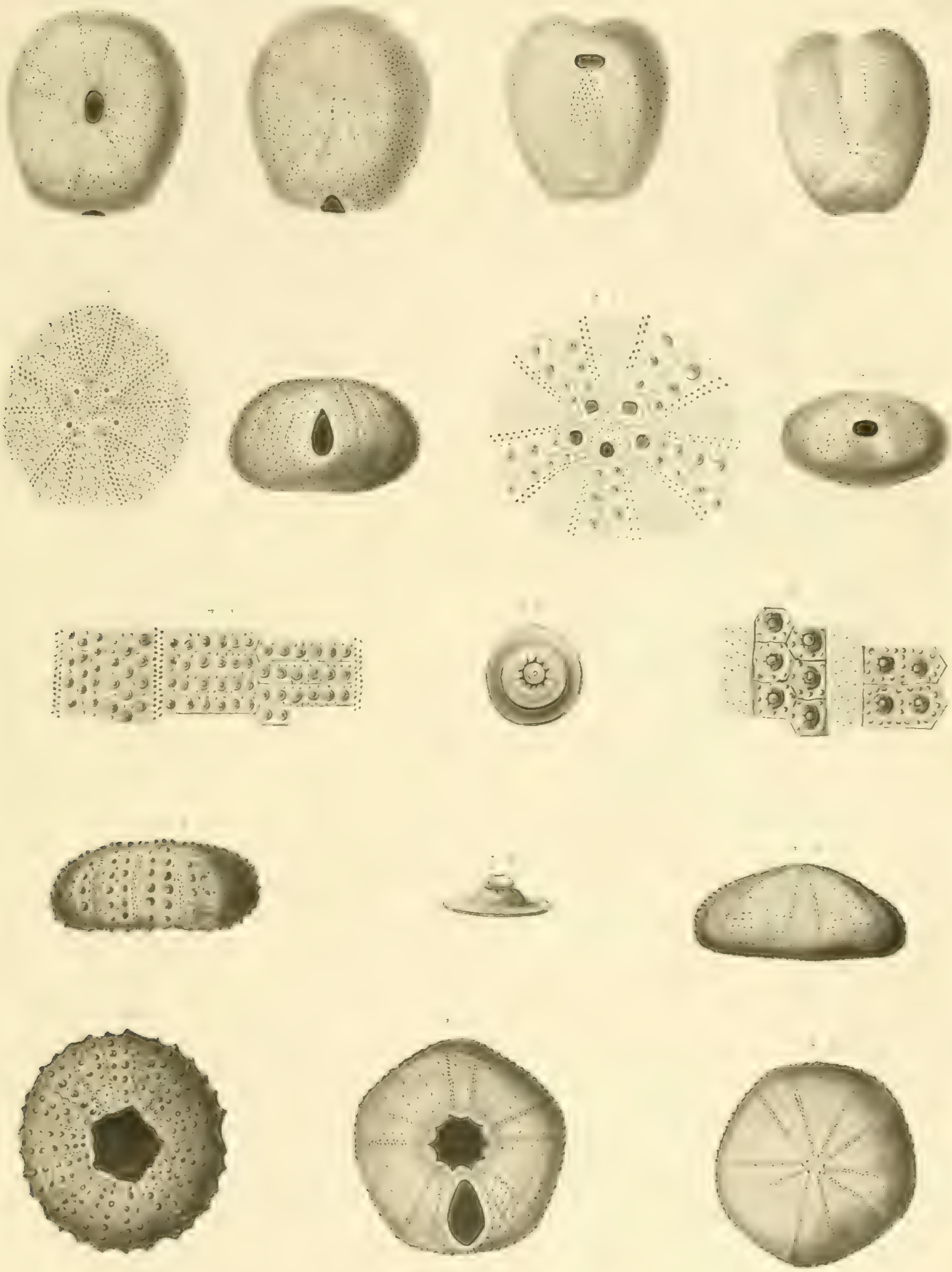
FIG. 5.—CARDITA SUBTETRICA.

FIG. 6.—CAPSA TEXANA.

FIG. 7.—TURRITELLA LEONENSIS.

Fig. 7 *a*, *b*. Two views of the same individual.

FIG. 8.—HAMITES LARVATUS.



1 PYRINA PARRYI. 2 TOXASTER TEXANUS. 3 CYPHOSOMA TEXANUM. 4 HOLECTYPUS PLANATUS

1 CAPRINA OCCIDENTALIS 2 C. PLANATA 3 TURBINOLIA TEXANA

F. B. Meek del.

1 TEREBRATULA WACOENSIS. 2 TRIGONIA EMORYI. 3 TRIGONIA TEXANA.

F. B. Meek del. J. E. Gavit

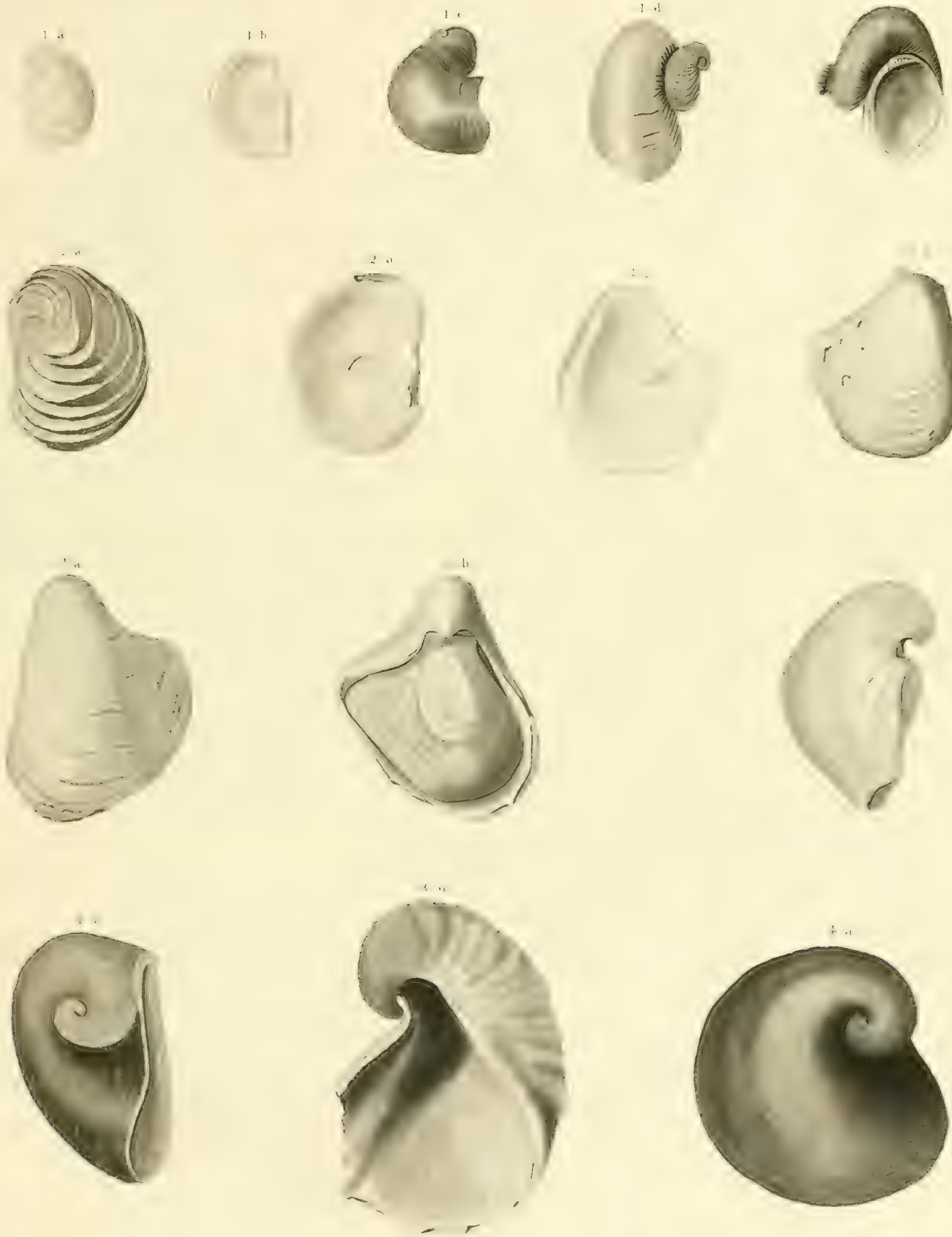
1. MACTRA TEXANA. 2. CUCULLEA TERMINALIS. 3. ARCOPAGIA TEXANA. 4. CARDIUM MEDIALE. 5. CYTHEREA NUTTALLII Eocene sp.

1 NEITHA OCCIDENTALIS. 2 NEITHA TEXANA 3 LIMA LEONENSIS 4 LIMA WACOENSIS 5 INOCERAMUS CONFERTIM-ANNULATUS
6 INOCERAMUS MYTILOPSIS. 7 INOCERAMUS TEXANUS 8 INOCERAMUS CRISPII. 9 ASTARTE TEXANA

F B Meek Del

1 CYTHEREA LEONENSIS. 2 C. TEXANA. 3 ARCA SUBELONGATA. 4 CARDIUM MULTISTRIATUM. 5 C. CONGESTUM. 6 C. TEXANUM. 7 C. FILOSUM

8 CARDITA EMINULA. 9 CORBULA OCCIDENTALIS. 10 PLICATULA INCONGRUA



F. B. Meek del. J. E. Gavit s

1. EXOGYRA ARIETENUM. 2. EXOGYRA FOLIACEA. 3. GRYPHÆA PITCHERI. 4. GRYPHÆA LÆVIUSCULA

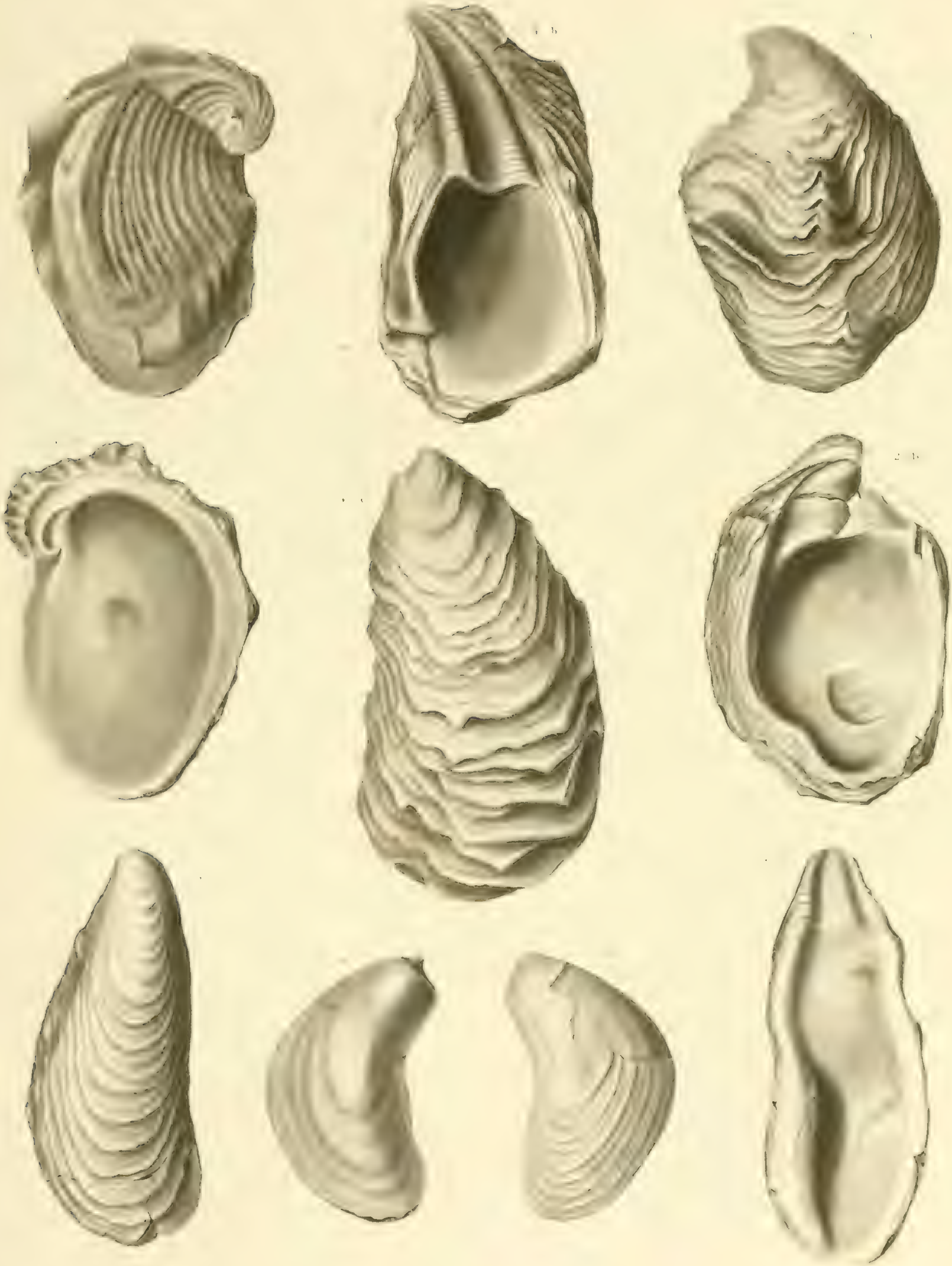
F. B. Meek del.

1 EXOGYRA MATHERONIANA. 2 EXOGYRA FRAGOSA. 3 EXOGYRA COSTATA VAR

1 EXOGYRA COSTATA VAR

F B Meek del J E Gavit

1 EXOGYRA COSTATA 2 GRYPHÆA PITCHERI 3 OSTREA SUBSPATULATA 4 OSTREA BELLA 5 OSTREA LUGUBRIS 6 OSTREA CARINATA



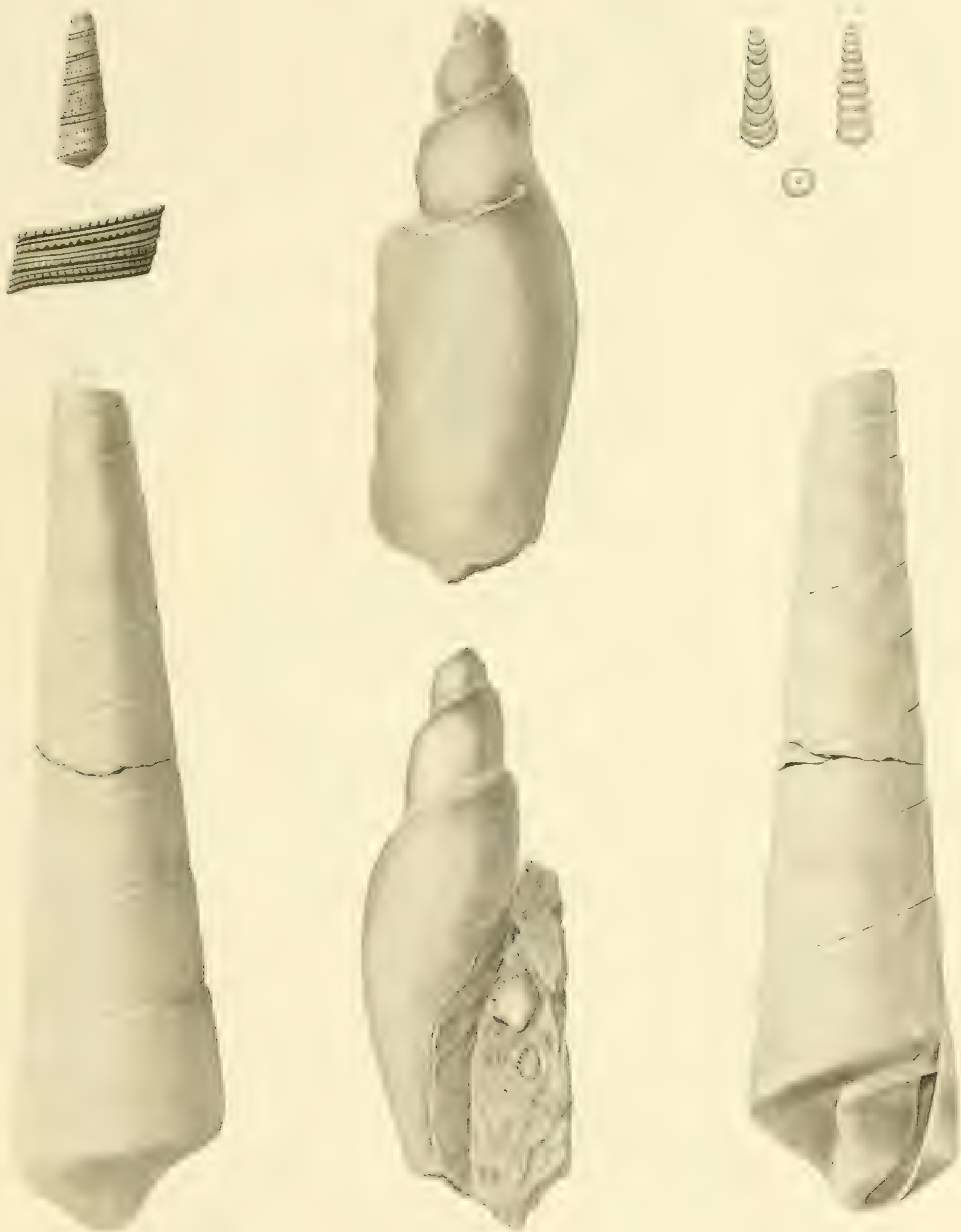
1 EXOGYRA MATHERONIANA 2 OSTREA VELLICATA 3 O ROBUSTA 4 O CORTEX

F. B. Meek del.

1 OSTREA MULTILIRATA

F B Meek del

1 NATICA TEXANA. 2 NATICA COLLINA. 3 ROSTELLARIA ? COLLINA. 4 ROSTELLARIA ? TEXANA. 5 BUCCINOPSIS PARRYI

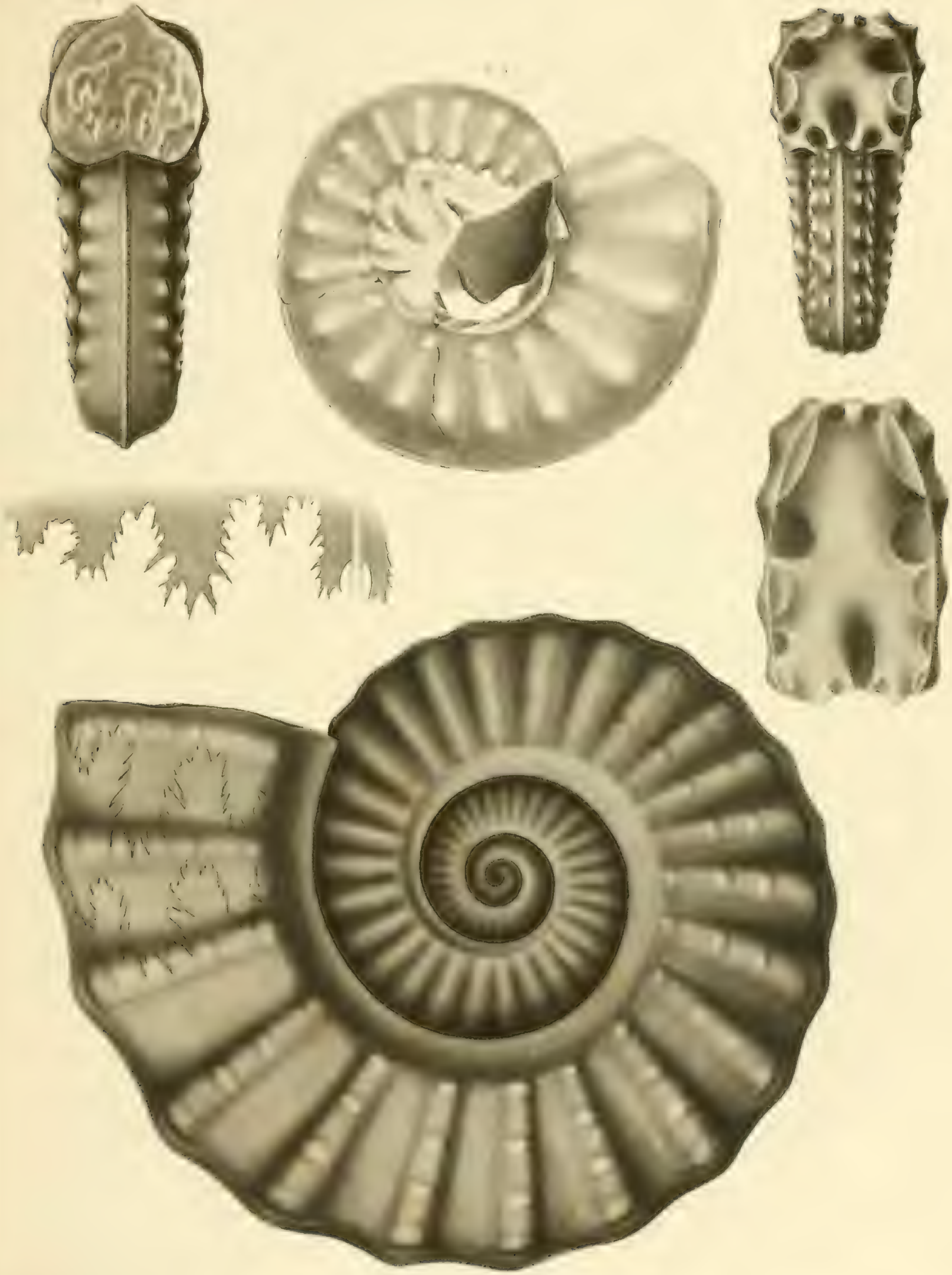


F. B. Meek del. J. E. Gavit sc.

1. TURRITELLA PLANILATERIS. 2. ROSTELLITES TEXANA. 3. NERINEA SCHOTTII. 4. NODOSARIA TEXANA.

F B Meek del

1 AMMONITES PEDERNALIS, VAR. 2 AMMONITES GENICULATUS



1 AMMONITES TEXANUS. 2 A. LEONENSIS

F. B. Meek Del.

1 OSTREA VESPERTINA. 2 O. VELENIANA

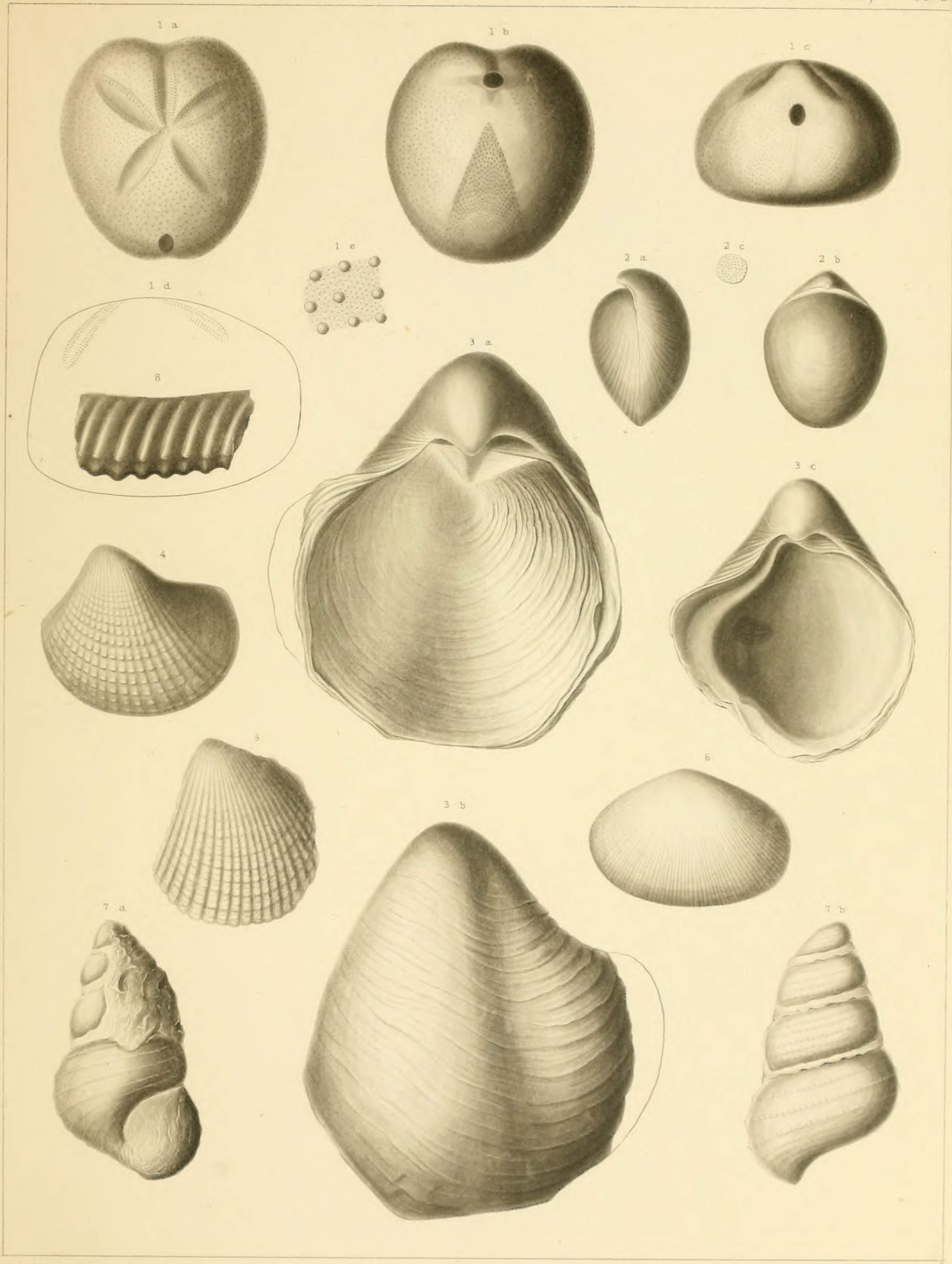
F B Meek del

1 OSTREA CONTRACTA

1 ANOMIA SUBCOSTATA. 2 CARDITA PLANICOSTA. 3 PHOLADOMYA TEXANA.(C 4 CORBULA NASUTA. 5 VENUS VESPERTINA
6 VOLUTILITHES SAYANA. 7 NATICA EMINULA 8 TURRITELLA 9 CASSIDULA [LACINIA] ALVEATA

F. B. Meek del.

1. COLUMNARIA THOMII. 2. TEREBRATULA MEXICANA. 3. ORTHIS ARACHNOIDES. 4. EUOMPHALUS MICHLERANUS. 5. ASAPHUS EMORYI.



F. B. Meek Del. W. H. Dougal Sc.

1 HOLASTER ELEGANS. 2 TEREBRATULA LEONENSIS. 3 GRYPHÆA PITCHERI. 4 PHOLADOMYA SANCTI-SABIÆ. 5 CARDITA SUBTETRICA.
6 CAPSA TEXANA. 7 TURRITELLA LEONENSIS. 8 HAMITES LARVATUS.